DOCUMENT RESUME

ED 319 623 SE 051 436

AUTHOR Giessow, Jean; Giessow, Fred
TITLE Exploring the Universe. Science Series Grades 4, 5, 6.
REPORT NO ISBN-0-88335-336-9
PUB DATE 90
NOTE 38p.; Contains reproducible pages plus teacher's guide. For another document in this series see SE 051 435.
AVAILABLE FROM Milliken Publishing Co., 1100 Research Blvd., St. Louis, MO 63132 (MP3148, $4.95).
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Aerospace Education; Aerospace Technology; *Astronomy; Elementary Education; *Elementary School Science; Instructional Materials; Intermediate Grades; Physics; Science Education; *Science Materials; *Space Sciences; Teaching Guides; Workbooks

ABSTRACT

The activities in this book are designed to reinforce elementary concepts in the study of the universe. General background information, suggested activities, questions for discussion, and answers are provided. Twenty-eight reproducible worksheets are contained in this guide. Topics include: the solar system, orbits, planets, the sun, forces in space, stars, comets, the history of astronomy, electromagnetic radiation, telescopes, spectroscopes, satellites and probes, Voyagers I and II, and the space shuttle. A crossword puzzle on astronomy is included. (CW)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

Exploring the Universe

ED319623

...RMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

Carole Garrett

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

- This document has been reproduced as received from the person or organization originating it.
- ☐ Minor changes have been made to improve reproduction quality.

- Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

SE051436

BEST COPY AVAILABLE

PLORING
E UNIVERSE

by Joan and Fred Giessow

The activities in this book reinforce basic elementary concepts in the study of the universe, including the planets, stars, comets, astronomers and their tools, and space travel.

General background information, suggested activities, questions for discussion, and answers are included.

Encourage students to keep completed pages in a folder or notebook for further reference and for review.

CONTENTS

The Solar System 1
Orbits 2
The Planets 3
Inner Planets 4
Outer Planets 5
Planet Review 6
The Sun 7
Features of the Sun 8
A Time Line of the Sun 9
The Sun's Opposing Forces 10
Sun Review 11
Stars 12
Star Size and Temperature 13
Comets 14
Halley's Comet 15
Early Astronomers: to the 1700s 16
Later Astronomers: The Herschel Family 17
Later Astronomers: 1700s to the Twentieth Century 18
Two Twentieth-Century Astronomers 19
Astronomers Review 20
Electromagnetic Radiation 21
Optical Telescopes 22
Radio Telescopes 23
Spectroscopes 24
Tools of the Astronomer Review 25
Satellites and Probes 26
Voyager 27
The Space Shuttle and Beyond 28

©MILLIKEN PUBLISHING COMPANY

Exploring the Universe: Background Material

Our knowledge of the universe is constantly being updated as new information is received from satellites. The material in this book should be used as a springboard for study and as a foundation for further research. The units in this book may be taught separately, as there is a review page at the end of most sections. However, it is suggested that the subject of the universe be considered in its entirety.

Pages 1-6 Stars and planets differ in that stars produce their own heat and light. Planets revolve around the sun in elliptical orbits. There are four inner planets and five outer planets (often called, except for Pluto, the "gas giants"). *Voyager II*'s recent flyby of the gas giants revealed many unknown features, such as new moons, rings, and atmospheric conditions. Recent sources should be consulted when studying the outer planets.

Pages 7–11 The sun is a mass of gases; its intense radiation is produced by the nuclear fusion of hydrogen atoms into helium. This outward radiating energy is balanced by the contrasting force of gravity. Imbalances in these two forces lead to the different stages in a star's life. Sunspots, flares, prominences, and eclipses are features of the sun. Although eclipses may be the most visually dramatic phenomena, flares and sunspot activity (particularly in the peak of the 11–year cycle known as Solar Maximus) can have drastic effects on communication satellites and weather patterns here on earth.

Pages 12–15 Only stars in the Milky Way galaxy can be seen without a telescope. Proxima Centauri, Sirius, Betelgeuse, and Polaris are some of the more well-known stars. As stars go through different stages, their temperatures vary considerably. Our sun is a yellow dwarf star. Comets are loose collections of gravel, ice, dust, and gas that orbit the sun, often in extremely long periods of hundreds or thousands of years. Astronomers believe many comets come from a far corner of the solar system called the Oort cloud. The sun vaporizes part of the comet each time it approaches; debris from comets continually enters the earth's atmosphere as meteorites or "shooting stars." Halley's Comet, first sighted in 240 B.C., is the world's best-known comet.

Pages 16–20 The ancient Greeks developed ideas about the universe that were held for over fifteen hundred years. It was not until the sixteenth century, however, that modern astronomy (based on observation and mathematics) began to overturn theories of an earth–centered universe. Since then, countless discoveries have been made—including nebulae, supernovae, quasars, pulsars, cepheids, clusters, and many other stellar phenomena.

Pages 21–28 Scientists have gained nearly all of their knowledge about the universe through detailed analyses of the electromagnetic radiation received from heavenly bodies. EMR includes all light energy—from x–rays (very short wavelength) to radio waves (very long wavelength). Early telescopes utilized only visible light, but telescopes have since been developed to gather radio, ultraviolet, x–rays, and microwave radiation, as well. Spectroscopes are used to break light into its composite wavelengths to determine the material source. Probes and satellites—equipped with basic telescopes, spectroscopes, cameras, and other measuring devices—have enabled scientists to obtain close–up observations of almost every part of the solar system. Reusable spacecraft, such as the Shuttle, further contribute to astronomical discovery, but their role is primarily to develop the capacity for humans to work in space.

Exploring the Universe: Answers

Page 2
Mercury, 88 days; Venus, 224.7 days; Earth, 365.25 days; Mars, 1.88 years; Jupiter, 11.86 years; Saturn, 29.5 years;

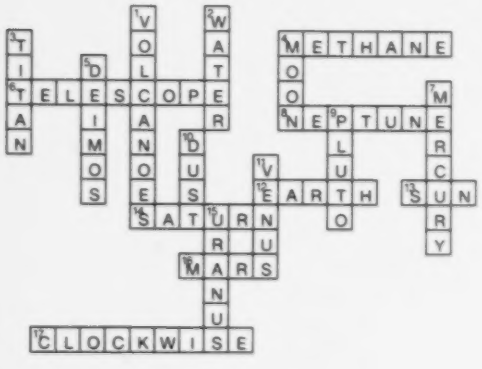
Uranus, 84 years; Neptune, 164.79 years; Pluto, 248.32 years; MISSILE–TOE.

Page 3
Jupiter; Pluto; Mars; Uranus; Saturn; Venus; Pluto; Saturn; Venus and Earth; Mercury and Venus; Pluto, Mercury, Mars, Venus, Earth, Neptune, Uranus, Saturn, Jupiter

Page 4
A Mercury–year equals 88 days.
Earth's tilted axis leads to more direct sunlight, causing summers or less direct sunlight, causing winters.

Page 5
See encyclopedia under Saturn.
Uranus is believed to have been hit by a comet or meteor which knocked its axis ninety degrees out of line. Voyager would have passed Neptune after Uranus, so six of Neptune's moons were discovered after 1986.

Page 6
Planets in order from sun: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto



Page 7
See page for answers.
a. corona b. core c. outer layer
d. chromosphere e. middle layer

Page 8
1. prominence 2. flare 3. sunspot; The right picture is a lunar eclipse, the left, solar.

Page 9
Stars, stages, sun, trillion, hydrogen, helium, core, nuclear, energy, billion, Astronomers, red giant, collapse, cool, visible

Page 10
balanced, radiation energy, expands, gravity, shrinks.

Page 11
ASTRONOMER; False statements rewritten: 1. 5.2 billion years ago the sun's temperature was –273°C. 3. The sun's light takes eight minutes to reach the earth. 4. A lunar eclipse occurs when the earth prevents the sun's light from reaching the moon. 6. Nuclear fusion is a process of converting matter into energy. 7. Prominences are bright arches of flaming gases rising above the sun's surface. 9. In the sun's core, hydrogen atoms are fused into helium atoms. 10. Electrical and gravitational forces can cause objects to move together.

Page 12

Y	X	A	L	A	G	R	S	E	T	I	H	W	L	
A	V	O	N	R	E	P	U	S	H	U	N	F	I	
W	T	E	O	L	I	N	N	U	T	S	A	L	R	
Y	V	A	R	I	A	B	L	E	R	A	I	B	U	
K	I	L	D	T	S	N	O	G	A	M	R	O	A	
L	K	M	E	A	O	M	I	L	E	Y	A	V	T	
I	C	O	R	I	G	E	L	E	B	A	O	T	N	
M	A	B	R	I	G	H	T	T	S	N	W	P	E	
T	N	O	I	T	A	L	L	E	T	S	N	O	C	
R	I	G	S	O	D	H	U	B	C	I	L	L	A	
I	S	R	B	O	L	S	D	W	A	R	F	A	M	
L	M	A	G	N	I	T	U	D	E	I	R	R	I	
L	A	V	T	A	L	N	S	V	O	U	L	I	X	
I	O	J	I	B	Y	R	A	N	I	B	S	E	S	O
O	O	T	S	A	L	T	G	H	T	Y	E	A	R	
N	R	Y	B	I	N	G	A	D	O	I	R	E	P	

Page 13
See page for labels and color. Chart: white dwarf—7000°C; red giant—2500°C; yellow dwarf—6000°C; black dwarf—–270°C.

Page 14
1. the sun 2. the sun 3. away from
4. chunks of ice, gravel, dust, and gas
5. meteor or shooting star 6. International Cometary Explorer

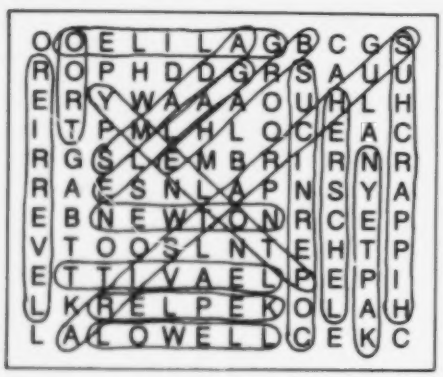
©MILLIKEN PUBLISHING COMPANY

Page 15
Halley's Comet period equals 76 years. Next ten visits: 2061, 2137, 2213, 2289, 2365, 2441, 2517, 2593, 2669, 2745.

Page 16
Eudoxus, Aristarchus, Hipparchus, Ptolemy, Copernicus, Brahe, Kepler, Galileo, Newton.

Page 17
astronomy, telescope, Uranus, Herschel, comet; PHOTOMETRY.

Page 18



Page 19
1. There are many nebulae. The Crab nebula and the Horsehead nebula are two of the more famous ones. 2. Andromeda Galaxy is nearest the Milky Way. 3. It is spiral. 4. The Hubble Telescope is a reflecting telescope designed to be placed in the earth's orbit to free it from atmospheric interference.

Page 20
(blanks) astronomy, Saturn, telescope, rotation, orbit, Neptune, Oort, Milky Way, elliptical, revolution, sun (matching) 2, 8, 1, 3, 6, 7, 4, 9, 5, 10 (completions) 1. earth; sun 2. sun 3. galactocentric 4. galaxies

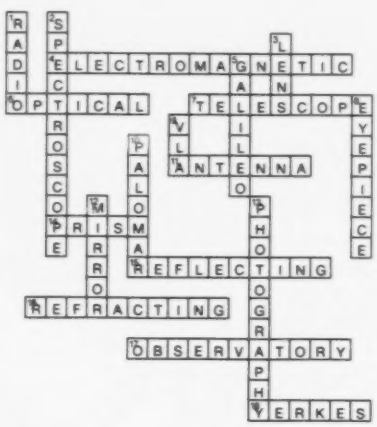
Page 21
1. visible light, radio waves, some infrared, and some ultraviolet rays.
2. above the earth's atmosphere.
3. Scientists had been unable to get far enough above the atmosphere to detect x-rays until then.

Page 22
Currently the world's largest reflecting telescope is in the Ural Mountains of the U.S.S.R. but a larger one (diameter 10 meters) is expected to be completed by 1995 on Mauna Kea, Hawaii's highest mountain.

Page 23
O marks indicate major optical telescope locations.

Page 24
The "red shift" is a shift in the color pattern of a heavenly body toward the longer (red) wavelengths. The amount of red shift indicates the speed at which an object travels away from earth. In 1929 Hubble discovered that the red shift could be used to determine the distances to other galaxies and that every galaxy is moving away from every other galaxy. Therefore, he concluded, the universe is expanding.

Page 25



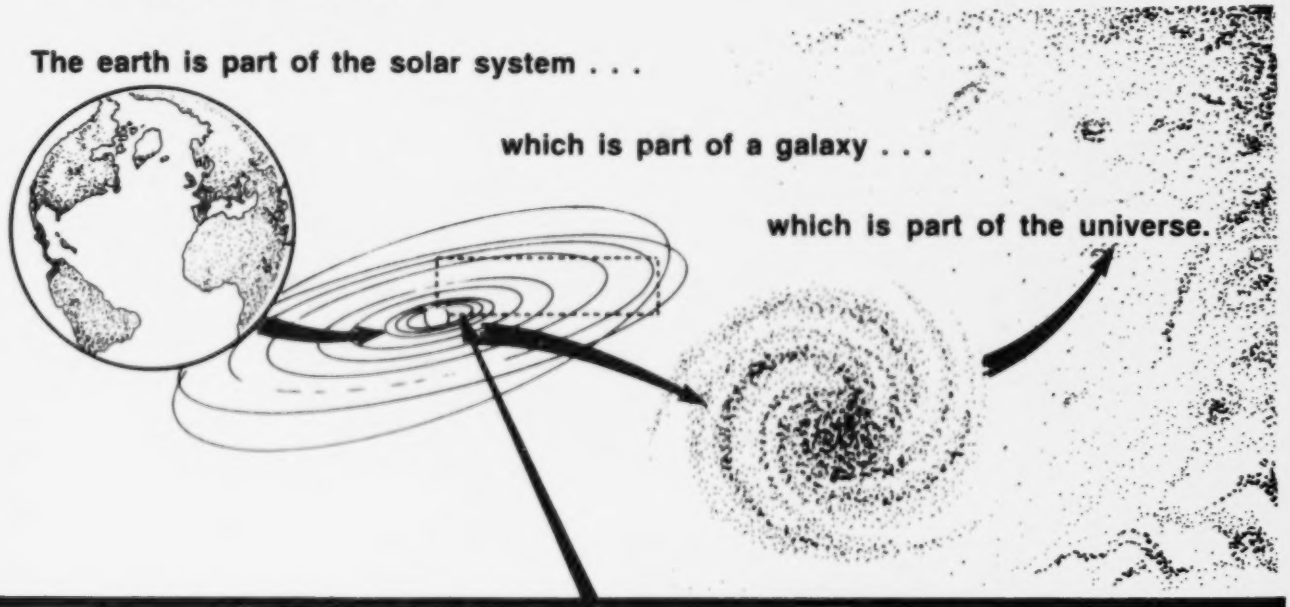
Page 26
Mariner II (P)–1962–to Venus; *Mariner IV* (P)–1965–to Mars; *Pioneer* 10 (P)–1973–76–outer planets; *Galileo* (P)–1989–to Jupiter; *Skylab* (S)–1973–1979–1st manned orbiting lab; *Viking I* (P)–1976–1st landing on Mars.

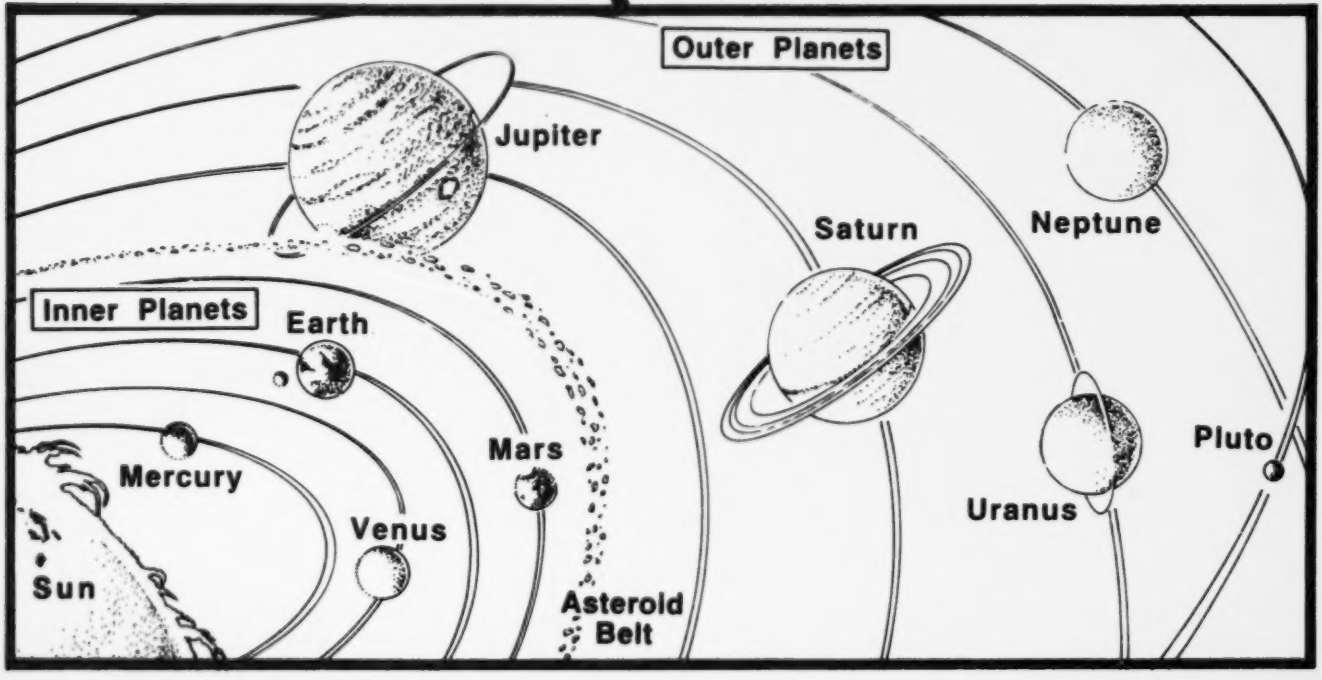
Page 28
1. 1957 2. *Mariner IV* 3. probe outer planets 4. *Skylab* 5. *Voyager I* and *Voyager II* 6. active volcanoes
7. *Voyager II* 8. *Columbia*, *Discovery*, *Atlantis* 9. Sally Ride 10. 100

THE SOLAR SYSTEM

Everything in space is part of the universe. The **solar system** consists of the sun and nine known planets that revolve around it. The sun is just one star of the 100 billion or so which make up the **Milky Way** galaxy. In the universe, there are millions of other galaxies, each containing billions of stars.

Stars and planets differ. Stars produce and give off their own heat and light; planets reflect the light of the sun. Between the planets orbit **asteroids**, chunks of rock and metal, and **comets**, loose collections of rock and frozen gas.



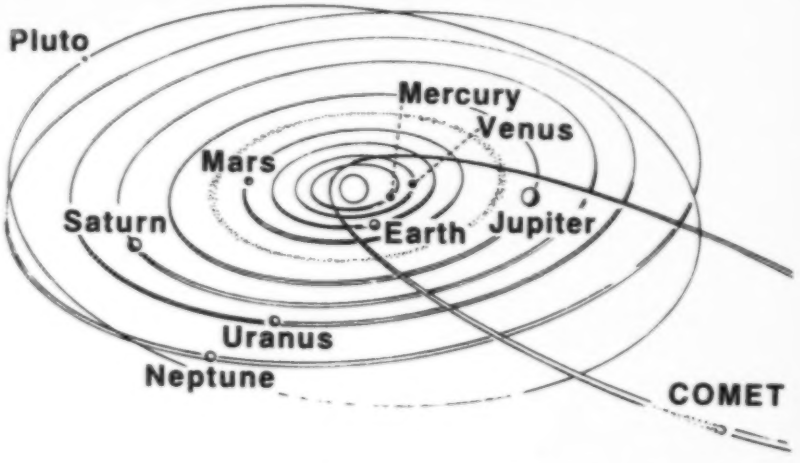


©MILLIKEN PUBLISHING COMPANY

ORBITS

The planets revolve around the sun. Their paths, called **orbits**, may be elongated or nearly circular. The time it takes to complete an orbit is known as a **period**.

Time to Complete One Orbit	
Mercury	88 days
Venus	224.7 days
Earth	365.25 days
Mars	1.88 years
Jupiter	11.86 years
Saturn	29.5 years
Uranus	84 years
Neptune	164.79 years
Pluto	248.32 years



ACTIVITY Study the chart above. Then cover it and draw a straight line between the planet's name and its orbital period below.

Planets in order of distance from the sun	Period of one orbit
Mercury	365.25 days
Venus	11.86 years
Earth	88 days
Mars	84 years
Jupiter	224.7 days
Saturn	1.88 years
Uranus	248.32 years
Neptune	29.5 years
Pluto	164.79 years

Each line crosses a numeral and a letter. Print the letter above the numeral to answer the riddle below.

If athletes get athlete's foot, what do astronauts get?

				I			-			
1	2	3	4		5	6		7	8	9

©MILLIKEN PUBLISHING COMPANY

THE PLANETS

Name of Planet	Number of Satellites	Radius in km	Distance from Sun (A.U.*)	Period of Rotation	Period of Revolution
Inner Planets					
Mercury	0	2442 (1561 mi)	0.4	59 days	88 days
Venus	0	6051 (3758 mi)	0.7	243 days	224.7 days
Earth	1	6378 (3961 mi)	1	23.9 hrs	365.25 days (1 yr)
Mars	2	3397 (2037 mi)	1.5	24.5 hrs	1.88 yrs
Outer Planets					
Jupiter	16	71,371 (44,658 mi)	5.2	9.9 hrs	11.86 yrs
Saturn	23	60,337 (37,267 mi)	9.5	10.2 hrs	29.5 yrs
Uranus	15	26,214 (16,149 mi)	19	17 hrs	84 yrs
Neptune	8	24,747 (15,372 mi)	30	15.6 hrs	164.79 yrs
Pluto	1	1150 (770 mi)	40	6.4 days	248.32 yrs

*** Astronomical Unit: 1 A.U. = distance from Earth to the sun (approximately 150,000,000 kilometers)**

ACTIVITY Study the chart and answer the questions.

Which planet . . .

is the largest? _____ is the smallest? _____

has a rotation period most like Earth's? _____

orbits the sun in 84 years? _____ has the most satellites? _____

comes closest to Earth in its orbit? _____

has the same number of satellites as Earth? _____

has nearly the same rotation period as Jupiter? _____

Which planets . . .

are most nearly the same size? _____ have no satellites? _____

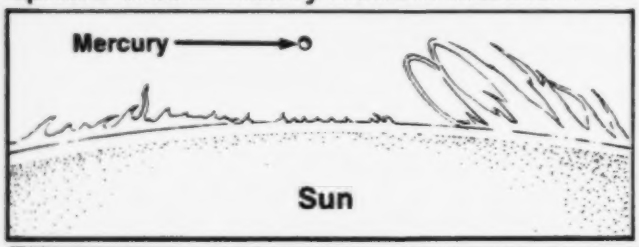
Rank the planets from smallest to largest. _____

_____

©MILLIKEN PUBLISHING COMPANY

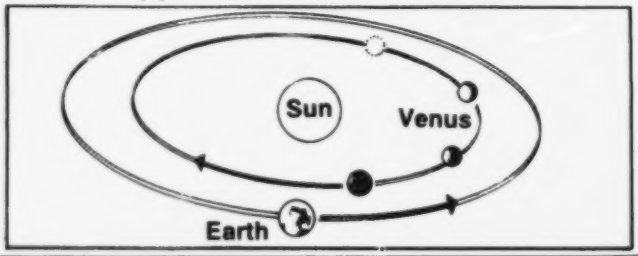
INNER PLANETS

Mercury is the small, rocky planet closest to the sun. It has a thin atmosphere that is mainly helium. *Mariner X* spacecraft showed that Mercury has hills, plains, craters, and mountains. It travels very fast around the sun, completing an orbit once every 88 Earth-days. Mercury's days are very long since it rotates once every 59 Earth-days.

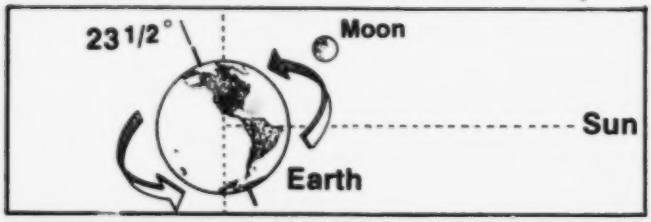


ACTIVITY How long is a "Mercury-year"?

Venus is the brightest object in the sky (except for the sun and moon) because its dense cloud cover reflects sunlight. This is the only planet that rotates in a clockwise direction. Like the moon, Venus has phases. Its surface is rocky and very hot—about 482°C (900°F). Its atmosphere is made of carbon dioxide and its upper clouds, sulfuric acid.



Earth, largely composed of rock and metal, is the only planet we know of that contains life. Because of Earth's nearly circular orbit, it receives a steady flow of heat and light from the sun. The rotation of Earth on its 23.5° axis allows gentle heating and cooling of the atmosphere, which is made up primarily of nitrogen and oxygen. Earth has one satellite, the moon, and an abundance of water.

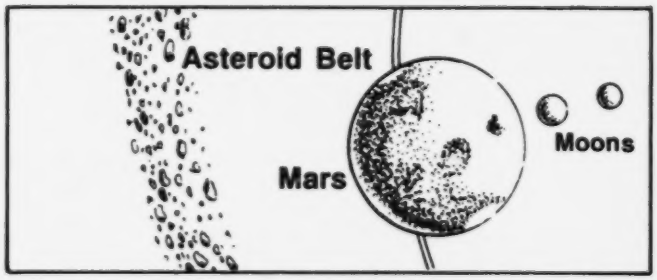


ACTIVITY Find out how earth's tilted axis causes it's seasons

---

Mars is about half the size of Earth and takes 1.88 years to orbit the sun. It has a thin atmosphere and, like Earth, has seasons. Spacecraft have taken pictures which show that Mars is dust-covered and has extinct volcanoes, some more than twice the height of Mt. Everest, which is 8.9 km (5.5 mi) high. Mars has polar ice caps and two moons—Phobos and Deimos.

Between Mars and Jupiter lies the Asteroid Belt, a collection of thousands of tiny planets, each orbiting the sun.



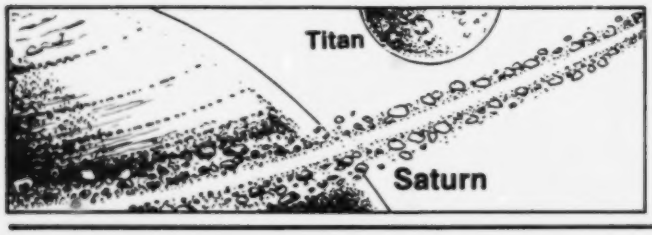
ACTIVITY Draw a picture of the inner planets and their orbits; show the direction of revolution for each.

©MILLIKEN PUBLISHING COMPANY

Outer Planets

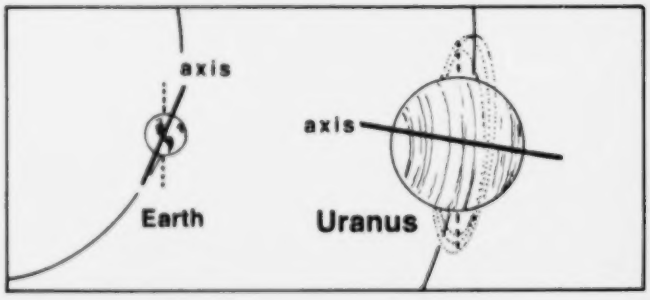
Jupiter, the largest planet in the solar system, is known for its Great Red Spot, which is believed to be a huge storm system. Its composition is mainly hydrogen and helium. Jupiter's atmosphere has alternating light and dark belts composed of gases moving at high speeds in opposite directions. Io, one of Jupiter's 16 moons, contains active extraterrestrial volcanoes.

Saturn, the second largest planet, has beautiful rings of boulders, pebbles, and ice. Saturn is made mostly of gases and is so light it could float on water. Saturn has 23 known moons. The largest, Titan, is bigger than the planet Mercury.

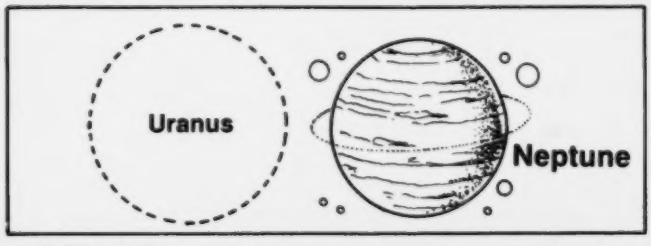


ACTIVITY Find the names of three other moons of Saturn.

Uranus, greenish in color, has 15 moons and 11 faint rings that were discovered in 1986. Unlike the other planets, it lies on its side as it orbits the sun. Its atmosphere is made primarily of methane gas. Uranus is the farthest planet that can be seen without a telescope.



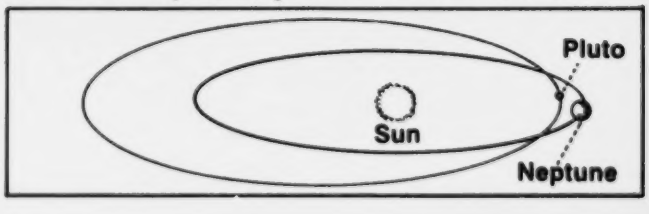
ACTIVITY Why do you think Uranus lies on its side?



Neptune is slightly smaller than Uranus. This distant planet has eight moons and a faint ring system. Its atmosphere is similar to that of Uranus, its neighbor, but has storm activity like Jupiter's atmosphere.

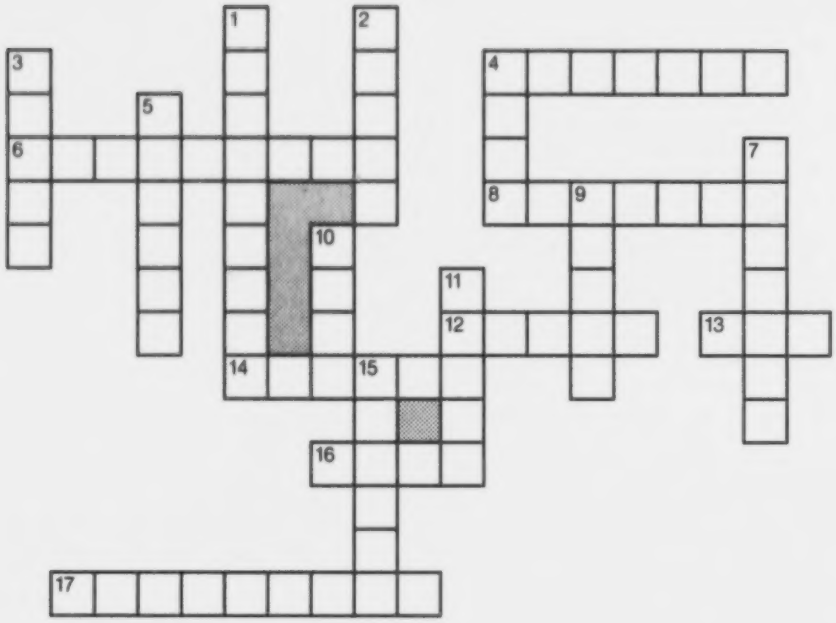
ACTIVITY If *Voyager 2* discovered six of Neptune's moons, would they have been seen before or after 1986?

Pluto was not discovered until 1930. It is so far away that it takes 248 Earth-years to orbit the sun. Between 1979 and 2000, Pluto's orbit takes it inside Neptune's orbit, so, it is not presently the most remote planet. Scientists have long wondered about the periodic "wobble" in Neptune's path around the sun. Pluto's mass is too small to influence Neptune's orbit, so there may be a tenth planet yet to be discovered.



©MILLIKEN PUBLISHING COMPANY

PLANET REVIEW



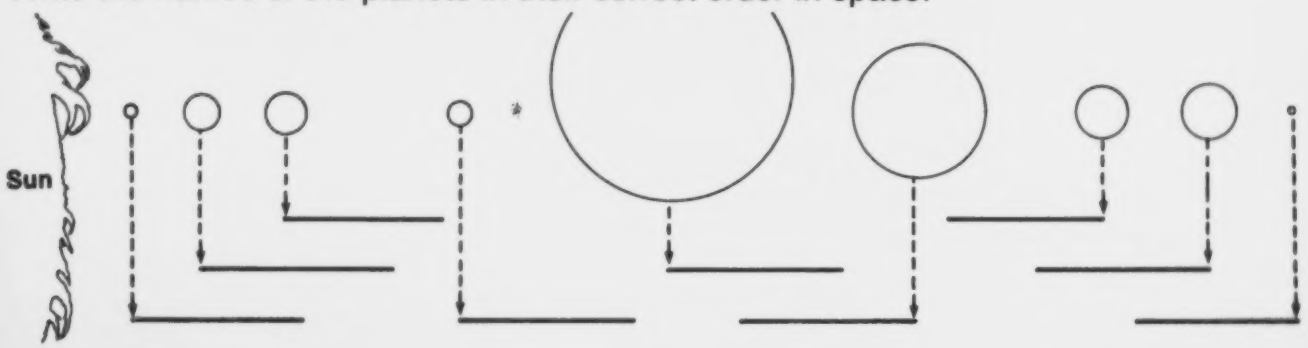
ACROSS

4. Uranus' atmosphere is mainly _____ gas.
6. Neptune can only be seen with a _____.
8. eighth planet from the sun
12. only planet with known life
13. Jupiter's surface is hotter than the ___.
14. ___ has twenty-three known moons.
16. planet with polar ice caps
17. Venus travels in a _____ direction.

DOWN

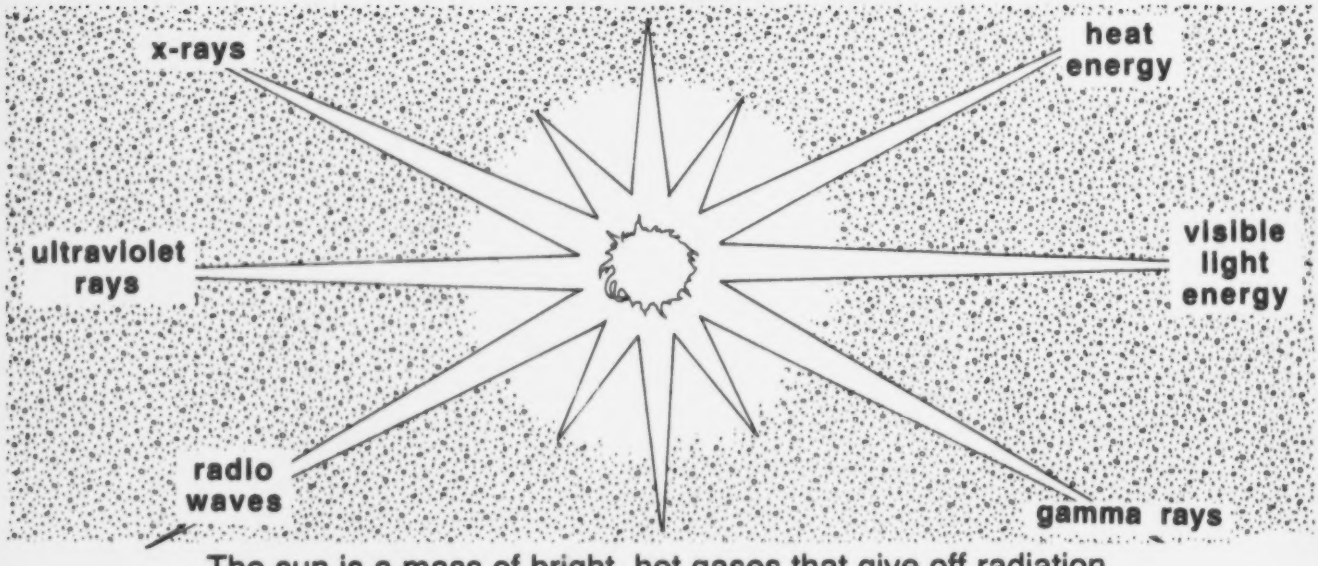
1. Jupiter has a moon with _____ .
2. Earth has plenty of _____ .
3. moon larger than Mercury
4. Venus has phases like the _____ .
5. one of Mars' moons
7. planet closest to the sun
9. not always the farthest planet from sun
10. Mars is covered with _____ .
11. the brightest planet
15. Two new rings were discovered on this planet in 1986.

Write the names of the planets in their correct order in space.



©MILLIKEN PUBLISHING COMPANY

THE SUN

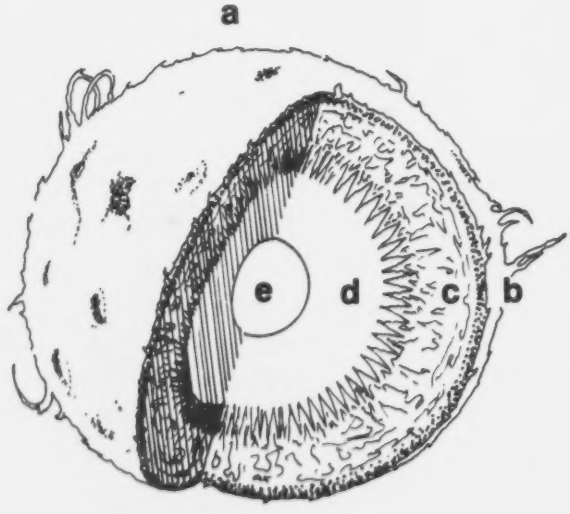


The sun is a mass of bright, hot gases that give off radiation.

The sun is the center of the solar system. Heat and light energy are produced by **nuclear reactions** within the sun. Even though the sun is an average-sized star, one million earths could fit inside it. The sun's diameter is 1,392,700 km (865,000 mi)—109 times that of the earth—and it is over 150,000,000 km (93,000,000 mi) away from earth. Its light, traveling at 300,000 km (186,000 mi) per second, takes eight minutes to reach earth. Less than two billionths of the sun's energy reaches earth, but without its heat and light, there could be no life on our planet. The surface temperature of the sun is nearly 5500°C (10,000°F), while the temperature of the **core** reaches 15,000,000°C (27,000,000°F).

The next layer away from the core is the middle layer, or **radiation zone**. Then comes the outer layer, or **convection zone**, which helps move heat from the core to the surface. The visible surface is called the **photosphere**. The **chromosphere**, which surrounds the photosphere, can reach temperatures up to 27,800°C (50,000°F). The cloud of gas surrounding the outermost layer is called the **corona**.

ACTIVITY Label the drawing of the sun.



Inside the Sun

a. _____ d. _____

b. _____ e. _____

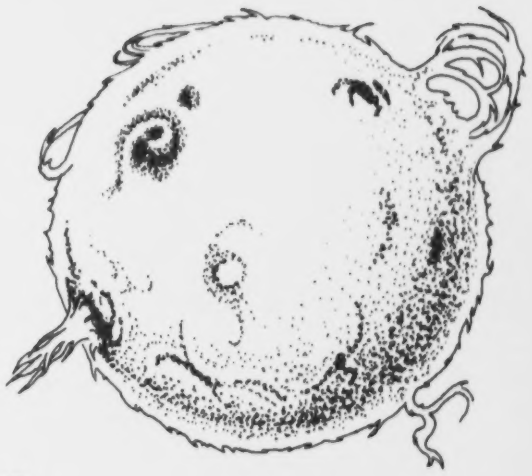
c. _____

©MILLIKEN PUBLISHING COMPANY

Features of the Sun

Solar Activity

On the sun's surface, dark patches called **sunspots** grow and disappear in regular cycles where gases have broken through the surface due to magnetic activity. **Flares** are powerful explosions which burst from sunspots or sunspot groups. **Prominences** are bright arches of gases which may reach 322,000 km (200,000 mi) above the sun's surface, the photosphere, before flowing back into it.



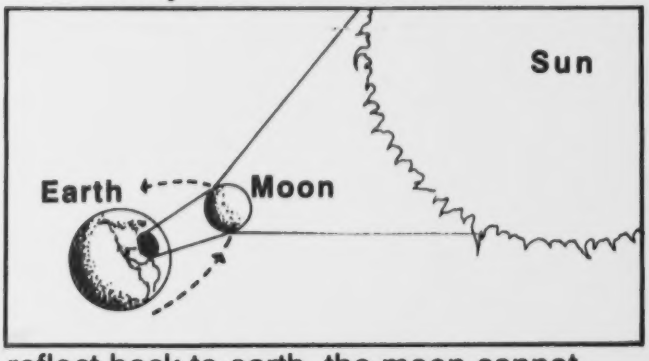
ACTIVITY Label the three features of the sun.

The Sun's Energy

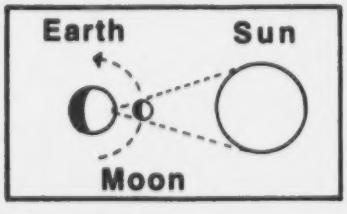
The sun's tremendous energy, which keeps the surface of the sun at 5500°C (10,000°F), is formed by **nuclear fusion,** a process that converts matter into energy. In the sun's core, the pressure and temperature are so great that hydrogen atoms are fused to become helium atoms. A small amount of mass is converted into a large amount of energy. The energy produced each second could provide the world with enough energy to last a million years. The energy from the sun's core takes millions of years to reach the surface.

Eclipses

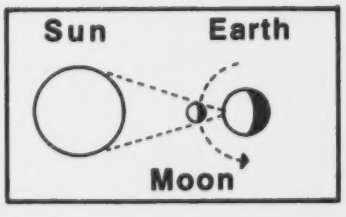
An **eclipse** occurs whenever one object blocks another from sight. There are two kinds of eclipses, **solar** and **lunar.** When the moon passes between the sun and the earth, the sun is blocked from view on earth. Because the sun is blocked, it is called a **solar eclipse.** When the earth passes between the moon and the sun, light cannot reach the moon. With no light to reflect back to earth, the moon cannot be seen. Because the moon is blocked, it is called a **lunar eclipse.**



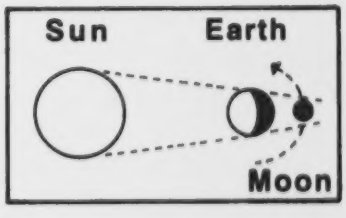
ACTIVITY Label the eclipses below as solar or lunar.



1. _____



2. _____



3. _____

©MILLIKEN PUBLISHING COMPANY

A Time Line of the Sun

ACTIVITY Use the information from the time line and the words from the word bank to reconstruct the life story of the sun.

WORD BANK

astronomers	collapse	cool	energy	helium
hydrogen	nuclear	visible	sun	stars
red giant	billion	core	stages	trillion

Sun's Diameter in Kilometers	Surface Degrees	Time in Years	
9.6 Trillion gas and dust	-270° C	5.2 billion	PAST
1,384,000	5500° C	5 billion	
1,384,000 Yellow Dwarf	5500° C	NOW	
1,384,000	5500° C	5 billion	
227,000,000 Red Giant	2500° C	6 billion	FUTURE
12,800 White Dwarf	7,000° C	15 billion	
12,800 Red Dwarf	2500° C	40 billion	
Black Dwarf	-273° C	1 trillion	

_____, as well as people, get older. Both go through different _____ in their lives. The _____ began six _____ years ago as a huge cloud of two gases: _____ and _____. Eventually, this gas cloud condensed, and the hydrogen in the _____ became hot enough and dense enough for _____ reactions to begin. Since these began, the sun has been able to produce _____ uniformly for over five _____ years. _____ believe that the sun can continue to produce energy in this way for another five billion years. Then the sun will gradually enlarge and become a _____. Eventually the sun will _____ and become about as small as the earth. It will no longer produce energy by nuclear reactions, but will gradually _____ off and, after billions of years, will no longer be _____.

©MILLIKEN PUBLISHING COMPANY

©MILLIKEN PUBLISHING COMPANY

THE SUN'S OPPOSING FORCES

The sun has been able to retain its size because of a balance between two forces that continually work against each other.

One force is the tremendous amount of **radiation energy** (**E**) that continually leaves the sun's core on its way to the surface. This force would cause the sun to expand if it were not for the other force, **gravity** (**g**).

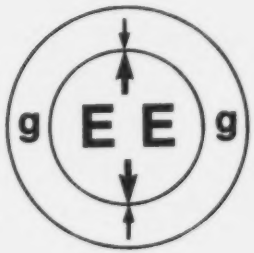
Gravity, a fundamental property of all matter, is the force of attraction between objects. Unlike electrical or magnetic forces, which can cause objects to move apart, the force of gravity always works to pull particles closer together. Within the sun, the gravitational forces between the molecules of hydrogen and helium attempt to pull the sun into a smaller-sized sphere. When the force due to the pressure of the heated molecules of hydrogen and helium is evenly balanced against the force of gravity, the sun neither expands nor contracts.

Use the words in the word bank to complete the sentences.

WORD BANK	expands	gravity	radiation energy
	balanced	shrinks	

The Sun

When the forces of energy and gravity are _____, the sun remains the same size.



When _____ in the center is greater than gravity then . . .

the sun _____ until the forces are balanced.

When radiation energy is less than _____ then . . .

the sun _____ until the two forces are equal again.

Sun Review

Read the following statements about the sun. If the statement is true, circle the letter under TRUE. If it is false, circle the letter under FALSE. Use the circled letters to answer this question: What do you call someone who studies stars and other heavenly bodies?

9	6	10	2	5	1	3	8	4	7
___	___	___	___	___	___	___	___	___	___

	TRUE	FALSE
1. 5.2 trillion years ago the sun's temperature was -270°C.	S	N
2. One million earths could fit into the sun at its present size.	R	C
3. The sun's light takes eight years to reach the earth.	I	O
4. A solar eclipse occurs when the earth prevents the sun's light from reaching the moon.	R	E
5. The outermost part of the sun is the corona.	O	N
6. Nuclear fusion is a process of converting energy into matter.	T	S
7. Prominences are bright arches of flaming gases rising above the sun's surface.	R	I
8. Gravity is a fundamental property of all matter.	M	S
9. In the sun's core, helium atoms are fused into hydrogen atoms.	R	A
10. Electrical and gravitational forces can cause objects to move apart.	S	T

On another paper, rewrite the false statements to make them true.

©MILLIKEN PUBLISHING COMPANY

STARS

All the stars seen without a telescope belong to the Milky Way galaxy. The closest star besides the sun is Proxima Centauri, 4.3 light years away. A light year is the distance light travels in a year—about 9.6 trillion km (6 trillion mi). Betelgeuse, a giant red star, is 200 light years away. Rigel, a supergiant, is 540 light years away. Both very bright stars are in the constellation Orion. The farthest stars are in galaxies billions of light years away.

The brightest star in the night sky is Sirius, the Dog Star, 8.8 light years away. It is a blue-white star in the constellation Canis Major. Sirius is of the first magnitude, a designation indicating the brightness of a star. It is 30 times brighter than the sun. Sirius has a companion star which was the first white dwarf star discovered. A white dwarf is so dense that one cubic inch of its matter would weigh one ton on earth. Two stars revolving around a common center of gravity are called binary stars.

Variable stars are those whose brightness pulsates, or increases and decreases periodically. The North Star, Polaris, is a pulsating variable with a period of about four days. Some stars have periods of hundreds of days. A nova is a star that suddenly increases in brightness and later returns to its original magnitude. A supernova is similar, but increases in brightness perhaps a million times and never completely returns to its original magnitude.

The oldest stars may be 12 billion years old. New stars are constantly being formed in interstellar space.

ACTIVITY Find the underlined words in the puzzle.

Y X A L A G R S E T I H W L
A V O N R E P U S H U N F I
W T E O L I N N U T S A L R
Y V A R I A B L E R A I B U
K I L D T S N O G A M R O A
L K M E A O M I L E Y A V T
I C O R I G E L E B A O T N
M A B R I G H T T S N W P E
T N O I T A L L E T S N O C
R I G S O D H U B C I L L A
I S R B O L S D W A R F A M
L M A G N I T U D E I R R I
L A V T A L N S V O U L I X
I J I B Y R A N I B S E S O
O O T S A L I G H T Y E A R
N R Y B I N G A D O I R E P

STAR SIZE AND TEMPERATURE

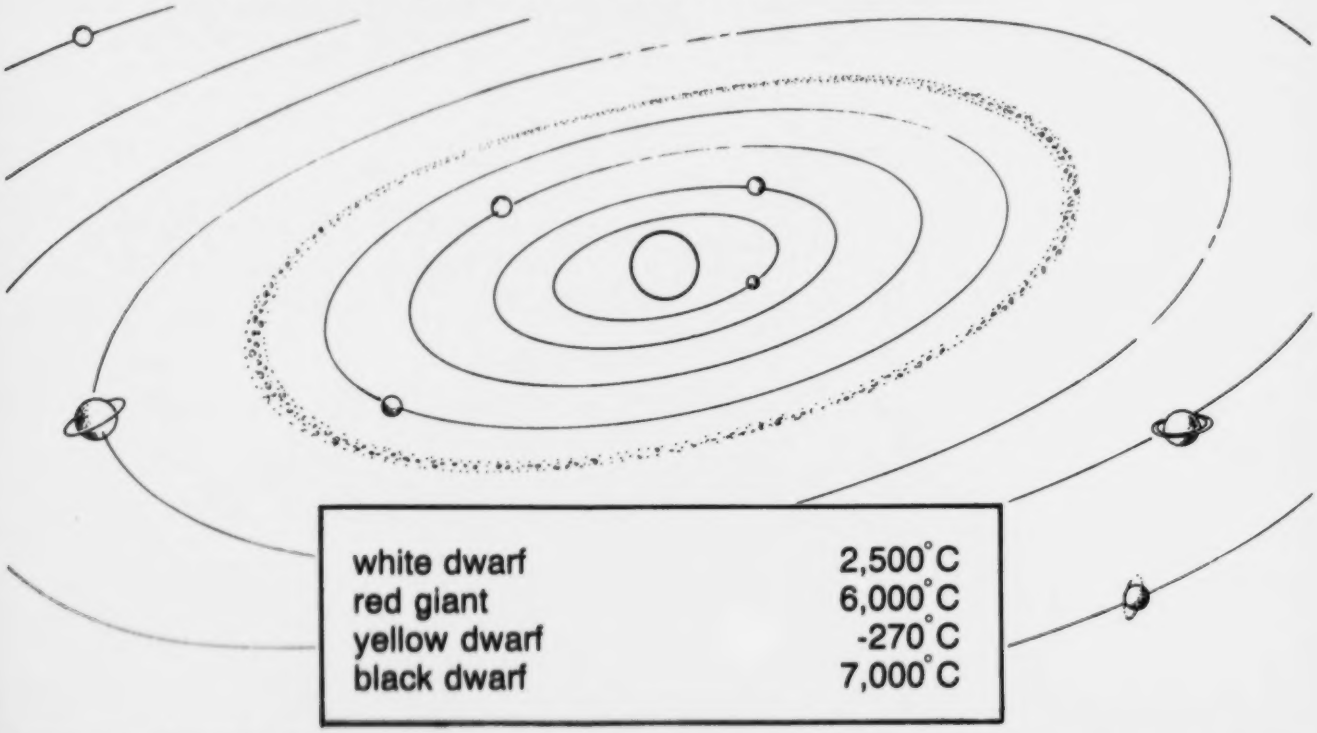
Stars go through different stages during their existence. The size of the sun, a **yellow dwarf**, will remain constant for another five billion years, at which time astronomers estimate that the energy radiating from the sun's core will increase. The outer layers will be forced farther out and the sun will expand, becoming a **red giant**. The surface temperature will be about 2,500°C (4,600°F). It will continue to expand until it is large enough to fill space out to Mars' orbit. Mercury, Venus, and Earth will be engulfed by the expanding sun.

The sun may remain a red giant for billions of years. Eventually, the red giant will shrink as the force of gravity becomes stronger than the core's radiation energy. This collapse will continue until the sun is compressed to the size of Earth. The heat from this final compression will be such that the temperature will be 7,000°C (12,600°F)—white hot. As a **white dwarf**, the sun will continue to lose energy to its cooler surroundings, and will gradually reach the **red dwarf** stage.

As the eons pass, the sun will continue to cool until it is barely hot enough to be visible. Finally, after about a billion years, all of its heat will have radiated into the surrounding space. The sun will then be a **black dwarf** with a temperature of almost absolute zero (-270° C).

Stars similar to the sun will have about an equal life span. Stars of larger mass may be brighter, but their life is shorter because they use helium atoms faster.

ACTIVITY Label the planets. Color in red the area the sun will fill when it is a red giant. Then match the star size with the temperature.



white dwarf	2,500°C
red giant	6,000°C
yellow dwarf	-270°C
black dwarf	7,000°C

©MILLIKEN PUBLISHING COMPANY

COMETS

Comets are perhaps one of the most spectacular sights in the sky. Astronomers are not sure where comets come from, but they believe that most originate in the far part of the solar system called the **Oort cloud**. Most comets move in elliptical orbits around the sun. Some orbits are so elongated that they move far out beyond Pluto.

Comets begin as a nucleus of ice chunks, gravel, dust, and gas. As the comet approaches the sun, the sun's radiant energy seems to push off part of the nucleus to form a **coma**, or head, around the nucleus. The coma may extend 1.6 million km (one million mi) from the nucleus. The sun's heat also vaporizes part of the material, forming a gas and dust **tail**. The coma and tail are always pointed away from the sun.

Comet tails can be 161 million km (100 million mi) long. Each time the comet passes the sun and forms a tail, part of the comet is lost through vaporization. Eventually, the whole comet disintegrates into stones, pebbles, dust, and gas. When these particles enter our atmosphere, they appear as **meteors,** or "shooting stars."

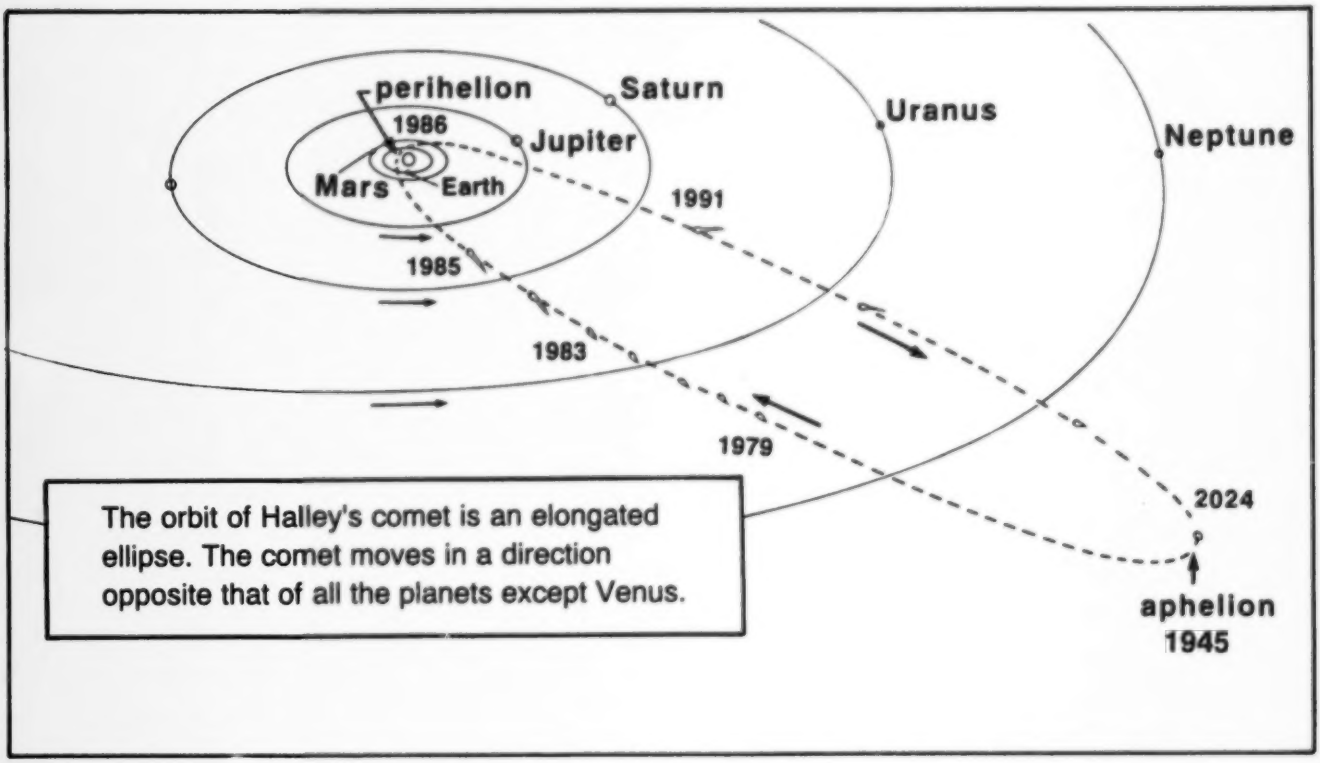
While there are probably billions of comets, we see very few. Some appear regularly, but others appear only once, never to be seen again. In September 1985, an American satellite successfully passed through the tail of a comet. This was the first time an artificial object encountered a comet. The satellite, called **ICE,** for **International Cometary Explorer**, spent seven years traveling toward its meeting with Comet Giacobini-Zinner (Jee-ah'-ko-**bee**' nee Zinner), 71 million km (44 million mi) from the earth.

ACTIVITY

1. Comets travel in elliptical orbits around _____.
2. As the comet approaches _____ , it forms a tail.
3. The tail always points _____ the sun.
4. The nucleus is composed of _____.
5. The debris of a disintegrated comet which enters the earth's atmosphere is called a _____.
6. The first satellite to encounter a comet was called _____.

©MILLIKEN PUBLISHING COMPANY

HALLEY'S COMET



The best-known comet is **Halley's comet.** The first recorded sighting was in 240 B.C.

In 1706, astronomer Edmond Halley, a friend of Sir Isaac Newton, published information concerning the orbits of 20 comets which had been previously observed. He discovered that comets in 1531, 1607, and 1682 had similar orbits and might be the same comet. He predicted that the next appearance of this comet would be in 76 years. True to form, the comet returned Christmas night, 1758. The comet was named for Halley, who died in 1742, although he was not the original discoverer.

By the time Halley's comet returned in 1910, telescopes and photographic equipment had improved so that excellent records of the comet's behavior were made. Halley's comet could be observed from space when it returned in late fall of 1985 in the Northern Hemisphere, reaching **perihelion** (pair-uh-**hee'**-lee-un) in February 1986. Perihelion is the point in orbit when the comet is closest to the sun. It is farthest from the sun at **aphelion** (uh-**fee'**-lee-un). Halley's comet will return in 2061. Its orbit will change slightly due to the influence of Jupiter's gravity. It will be more difficult to view from the earth because of city lights and pollution.

ACTIVITY How long is Comet Halley's period? Calculate the years of its next ten arrivals. How old will you be when it returns?

EARLY ASTRONOMERS: TO THE 1700s

In earlier times, people were aware of the apparent movement of the stars and **phases** of the moon. They realized that the sun warmed and lighted the earth but, because their observations were limited, many different theories were developed to explain stellar phenomena.

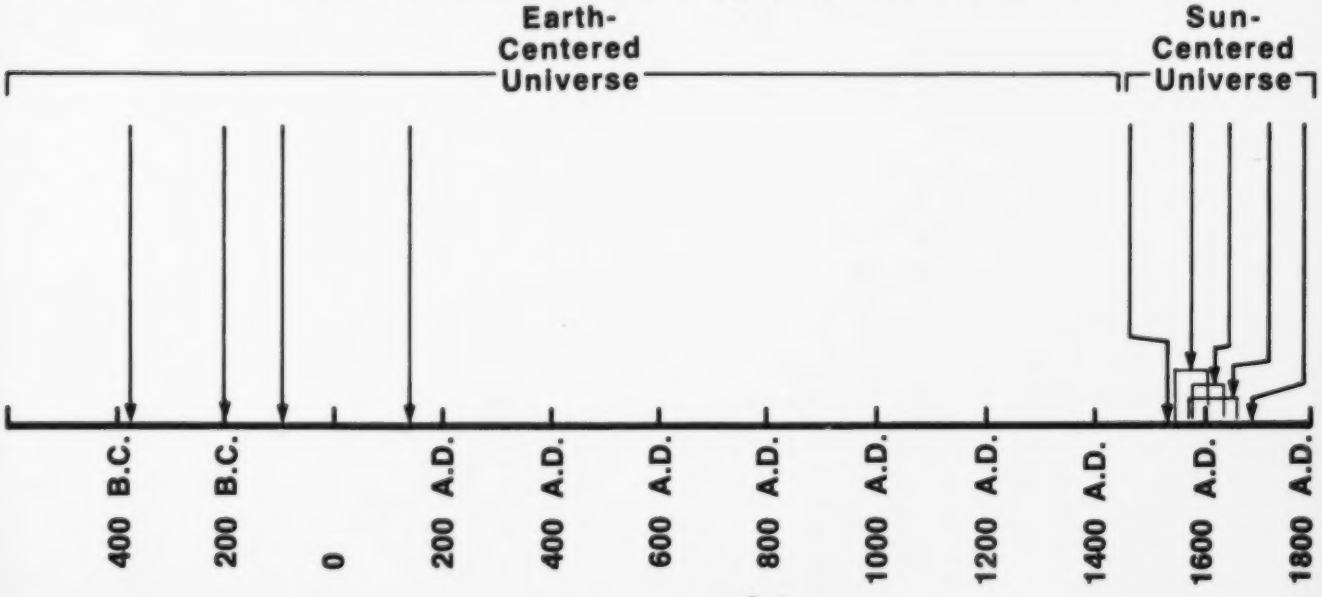
The ancient Greeks developed ideas about the universe which were held for over fifteen hundred years. First Eudoxus (c. 400-355 B.C.), and then Hipparchus (c. 100 B.C.), believed that the earth was the center of the universe. Only Aristarchus (c. 200 B.C.) thought that the sun was the center, but his idea was not widely believed. Another Greek, Claudius Ptolemy, perfected Hipparchus' theory of a stationary earth. About A.D. 150, he published *Almagest,* a book which became respected among Greek, Arab, and European scholars and scientists. In 1543, **Nicolaus Copernicus** revived the theory that the earth revolved around the sun, but it was difficult to prove.

Modern astronomy—based on observation—began with Danish astronomer Tycho Brahe (1546-1601). Johannes Kepler (1571-1630), a German mathematician, kept accurate records which showed that the planets traveled around the sun in elliptical orbits.

Meanwhile, **Galileo** (1564-1642), an Italian astronomer, was observing planets with his telescope. He discovered the phases of Venus and four moons orbiting Jupiter. He also studied the moon and the Milky Way galaxy. Galileo was an important early astronomer who laid the basis for **Sir Isaac Newton's** later work.

Born in 1642, the year Galileo died, Newton became a famous English astronomer and mathematician. He discovered the law of **gravity**—the basic principle of the universe—and the laws of motion.

ACTIVITY Place the astronomers in the correct places on the time line.



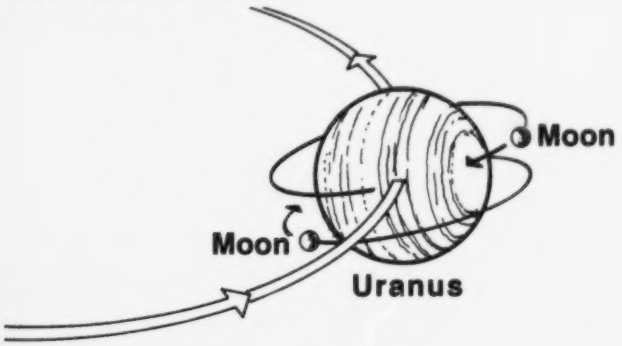
©MILLIKEN PUBLISHING COMPANY

LATER ASTRONOMERS: THE HERSCHEL FAMILY

Use the words from the word bank to fill in the blanks.

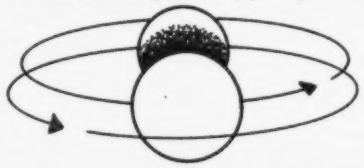
WORD BANK	astronomy	comet	Herschel	telescope	Uranus

The Herschel family made extraordinary contributions to the development of _ _ _ _ _ _ _ _ _ _ in the
4 5 10
eighteenth and nineteenth centuries. Sir William Herschel was born in Germany in 1738 and moved to England in 1757. He built his own _ _ _ _ _ _ _ _ _
8 7 1
to observe the heavens. He believed that by taking counts of stars in a small area of the sky, he could estimate the extent of the stars in the universe. Even today his star map of the Milky Way is fairly accurate. In 1781, Sir William discovered the seventh planet, _ _ _ _ _ _ ,
9
and two of its satellites. He also found that those satellites move in a backward, clockwise direction.



Herschel also discovered two satellites of Saturn, hundreds of double stars, and infrared radiation.

double-star (binary) system



Sir William's sister, Caroline _ _ _ -
_ _ _ _ _ (1750-1848), was also
2
born in Germany. She later joined her brother in England and, with his training, became an astronomer in her own right. She became the first woman to discover a _ _ _ _ _ and eventually
3 6
discovered seven more comets and three nebulae. In 1798, she revised Flamsteed's comprehensive catalog of stars.

Sir William's son, John (1792-1871), is well known for his observation of stars in the Southern Hemisphere. He also introduced the precise measurement of stellar brightness.

ACTIVITY Use the numbered letters in the underlined words to spell the word which tells what the process of precisely measuring stellar brightness is called.

_ _ _ _ _ _ _ _ _ _
1 2 3 4 5 6 7 8 9 10

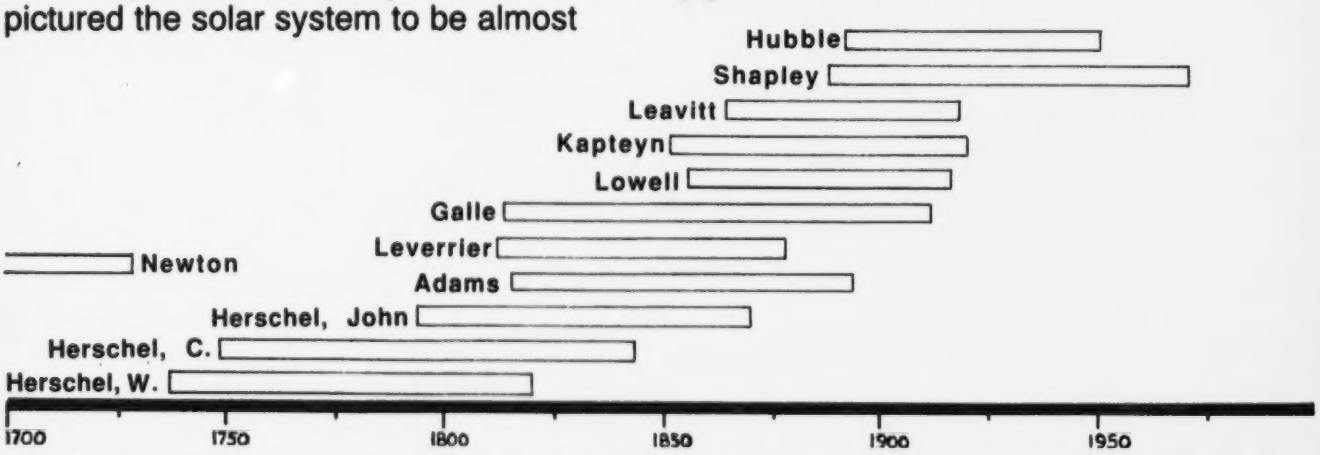
©MILLIKEN PUBLISHING COMPANY

Later Astronomers: 1700s to the Twentieth Century

After William Herschel discovered Uranus in 1781, other astronomers, Adams (1819-1892) of England and the Frenchman Leverrier (1811-1877), predicted that another planet existed. In 1846, German astronomer Johann Galle (1812-1910) discovered Neptune. American astronomer, Percival Lowell, (1855-1916) calculated that a more distant planet than Neptune orbited the sun. That planet, Pluto, was not seen until 1930.

Jacobus Kapteyn (1851-1922) wanted astronomers throughout the world to help him count stars within random patches of the sky in 1906. He pictured the solar system to be almost centrally located in a dense concentration of stars. He discovered that the Big Dipper, as well as other stars, were all moving in the same direction. One of Kapteyn's students, Jan Oort, later showed that the Milky Way galaxy also rotated. He is well known for his theory of the origin of comet formation.

Henrietta Leavitt (1868-1921) was an American astronomer from Harvard. Her research on the variation in the brightness of certain types of stars and star distances marked the beginning of the concept that earth and the stars in the Milky Way are only a small part of a gigantic universe.



Find these scientists' names in the puzzle.

Adams	Kapteyn
Aristarchus	Kepler
Brahe	Leavitt
Copernicus	Leverrier
Galileo	Lowell
Galle	Newton
Herschel	Oort
Hipparchus	Ptolemy

O	O	E	L	I	L	A	G	B	C	G	S
R	O	P	H	D	D	G	R	S	A	U	U
E	R	Y	W	A	A	A	O	U	H	L	H
I	T	P	M	L	H	L	O	C	E	A	C
R	G	S	L	E	M	B	R	I	R	N	R
R	A	E	S	N	L	A	P	N	S	Y	A
E	B	N	E	W	T	O	N	R	C	E	P
V	T	O	O	S	L	N	T	E	H	T	P
E	T	T	I	V	A	E	L	P	E	P	I
L	K	R	E	L	P	E	K	O	L	A	H
L	A	L	O	W	E	L	L	C	E	K	C

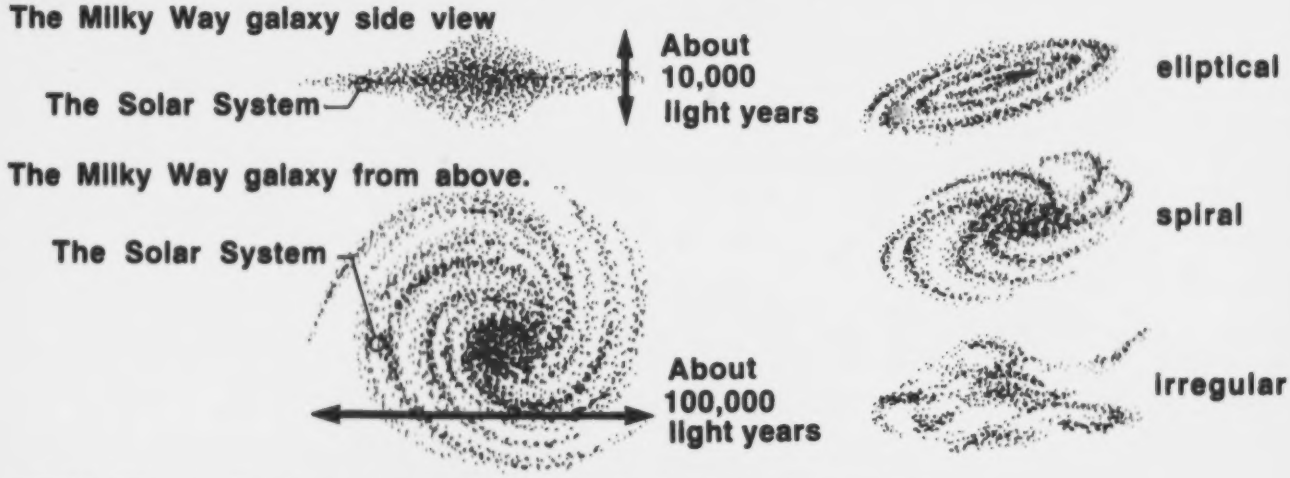
Two Twentieth-Century Astronomers

Two men from Missouri, **Harlow Shapley** and **Edwin Hubble**, did much to shape twentieth-century **cosmology**, the study of the universe.

Harlow Shapley (1885-1972) studied **globular clusters** containing tens of thousands of stars with the Mt. Wilson Observatory telescope. As a result of his observations, he decided that the sun was not situated in the center of the universe, as previously believed; rather, it was in a place a great distance from the center of the Milky Way galaxy. Not everyone accepted this radical new theory of a **galactocentric** (galaxy-centered) universe. Shapley debated Herber Curtis, who upheld the Kapteyn theory of a **heliocentric** (sun-centered) model, in 1920. Shapley's discovery was later accepted as one of the greatest revelations in modern astronomy.

Edwin Hubble (1889-1953), also on the staff at Mt. Wilson, discovered that **Cepheids**—stars whose brightness varies because of pulsations—were supergiants of very low magnitude. This meant that they were very distant, some as far as 20 million light-years distant. **Nebulae** are clouds of cosmic dust which may be bright or dark. In 1929, Hubble's investigations led to his discovery of the relationship of velocity to distance for nebulae, which was called Hubble's Law.

Hubble classified galaxies into various categories: irregular, elliptical, and spiral. The Milky Way galaxy is a spiral galaxy.



ACTIVITY

1. Find out the names of two well-known nebulae.
2. Which galaxy is nearest the Milky Way? _____
3. What kind of galaxy is it? _____
4. Find out more about the Hubble telescope, named for the famous astronomer. What is so special about it? _____

_____

ASTRONOMERS REVIEW

Fill in the blanks below.

A_____	the study of the heavens
S_____	a planet with rings
T_____	used for observing heavenly bodies
R_____	the spinning of a planet on its axis
O_____	the path of a planet around the sun
N_____	eighth planet from the sun
O_____	a man who studied under Kapteyn
M_____	the galaxy to which our solar system belongs
E_____	the type of path planets take
R_____	the movement of planets around the sun
S_____	once thought to be the center of the universe

Match the astronomers with their accomplishments.

1. Kepler	_____ discovered eight comets
2. Carolyn Herschel	_____ discovered Uranus
3. Oort	_____ discovered that the orbits of planets were elliptical
4. Galileo	_____ showed that our galaxy rotates
5. Ptolemy	_____ observed stars in the Southern Hemisphere
6. Sir John Herschel	_____ counted stars in random patches of the sky
7. Kapteyn	_____ discovered four moons of Jupiter
8. Sir William Herschel	_____ discovered the laws of motion
9. Newton	_____ thought the earth was the center of the universe
10. Galle	_____ discovered Neptune

Complete the following sentences.

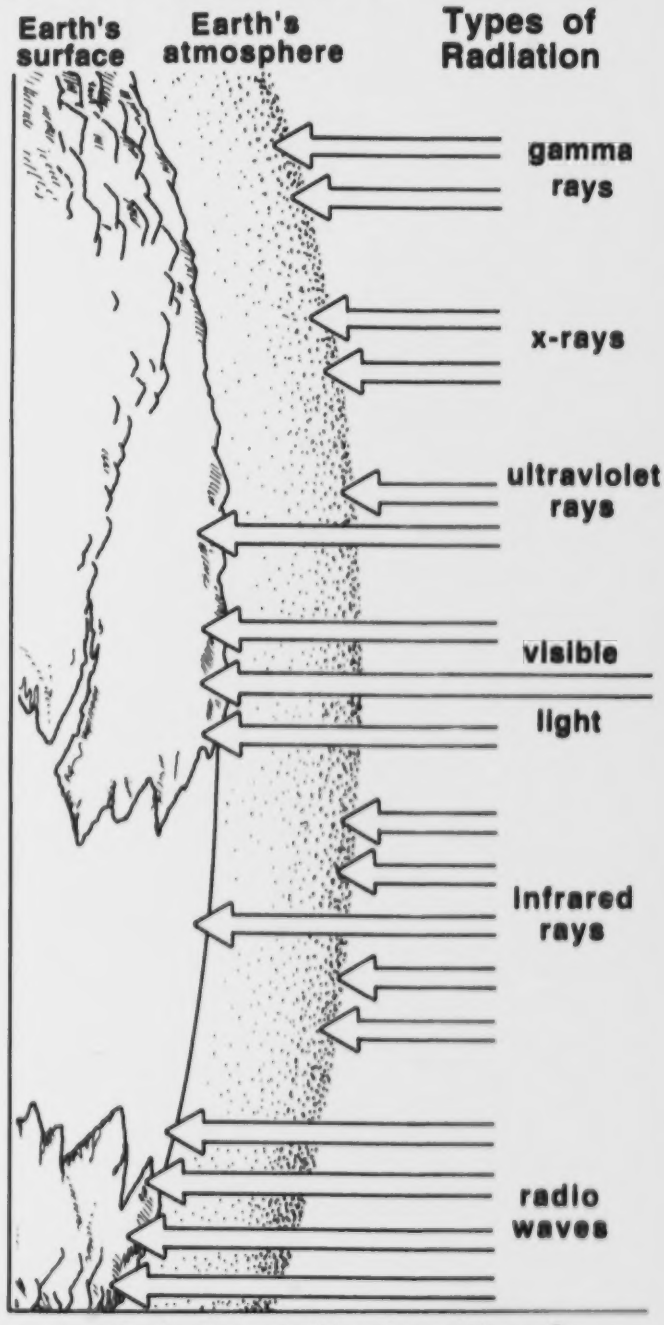
1. Copernicus thought that the _____ moved around the _____.
2. Aristarchus was an early astronomer who believed that the _____ was the center of our solar system.
3. Shapley's theory was a _____ model.
4. Hubble classified _____ into several categories.

ELECTROMAGNETIC RADIATION

Almost everything that astronomers have learned about planets, stars, interstellar materials, and galaxies has come from the various types of electromagnetic radiation that reach the earth. The term **electromagnetic radiation** refers to the different types of light energy, including x-rays, gamma rays, ultraviolet light, visible light, infrared light, microwaves, and radio waves.

Since only visible light can be detected directly by human beings, special instruments are attached to optical telescopes to make it possible to detect some of the other types of electromagnetic radiation. In other cases, special types of telescopes with auxiliary equipment are used to detect microwaves, radio waves, x-rays, and gamma rays.

Most types of radiation, depending on wavelength, are absorbed or scattered by earth's atmosphere. The diagram shows all of the kinds of visible and invisible radiation that can come from distant objects. It also shows the kinds that can penetrate the earth's atmosphere and reach the surface of our planet.



Types of Radiation

ACTIVITY 1. Which types of radiation can penetrate the earth's atmosphere?

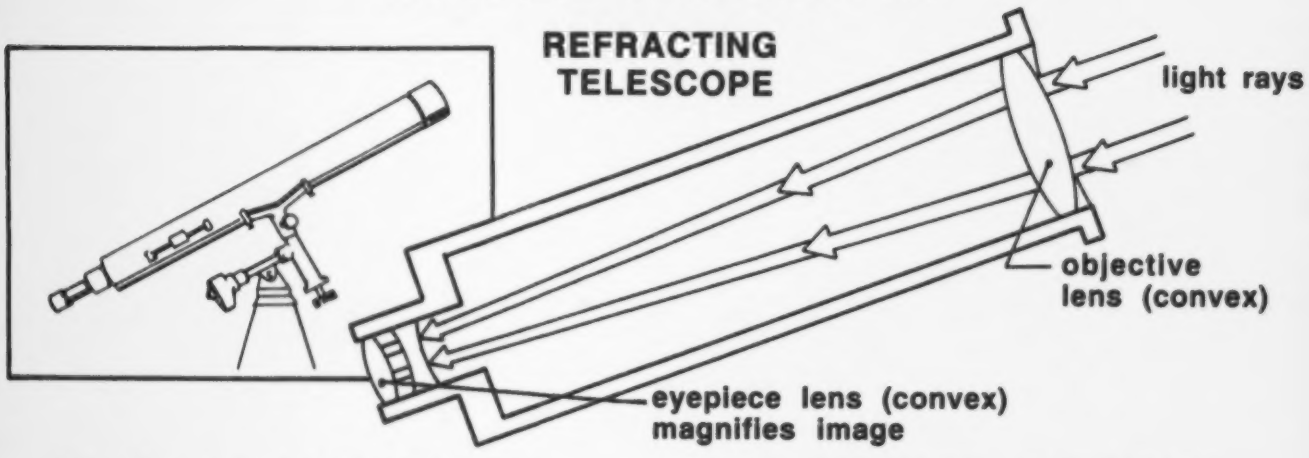
_____

2. If astronomers wanted to study x-rays given off by the sun, where would they have to put their telescopes? _____

3. William Roentgen discovered x-rays in 1897. Can you suggest why it was not known until 1955 that the sun sends x-rays to the earth?

_____

Optical Telescopes



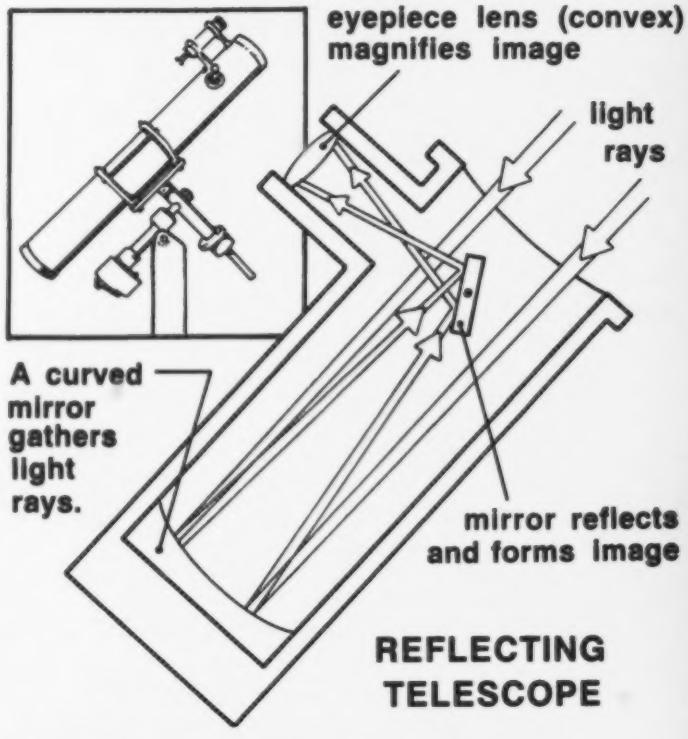
Amateur as well as professional astronomers have been using optical telescopes since 1608 when a Dutchman, Hans Lippershey, invented the first telescope. Galileo, the Italian astronomer, constructed his first telescope—a **refracting** type—in 1609. It enabled him to discover the rings of Saturn, four of Jupiter's satellites, and the craters on the moon.

A second type of telescope is the **reflecting** type, invented by Sir Isaac Newton. It is possible to build larger reflecting telescopes than refracting ones. They use mirrors instead of glass lenses to focus light rays.

A combination refracting-reflecting telescope was built in 1931 by a German optician, Bernhardt Schmidt. It can photograph large sections of the heavens.

Large telescopes are housed in **observatories**, most of which are in North America and Europe. An observatory has a special domed building which can revolve and open to allow the telescope to view different parts of the heavens.

The world's largest refracting telescope, with an objective lens diameter of 102 cm (40 in.), is at Yerkes Observatory in Wisconsin. Palomar Observatory in California is the home of the Hale telescope, the largest reflecting telescope in the Western Hemisphere. Its reflecting mirror is 508 cm (200 in.) in diameter.


eyepiece lens (convex) magnifies image
light rays
A curved mirror gathers light rays.
mirror reflects and forms image
REFLECTING TELESCOPE

ACTIVITY Find out where the *world's* largest reflecting telescope is and the diameter of its mirror.

RADIO TELESCOPES

As astronomers wanted larger and more efficient telescopes in order to study fainter and more distant objects, the need for a different kind of telescope became apparent.

Radio waves from space were first identified in 1931 by an American engineer, Karl Jansky. The **radio telescope** was developed after World War II. It has a huge saucer-shaped **antenna** that gathers radio waves emitted from far-off celestial bodies—nebulae, quasars, pulsars, and supernova. The waves are amplified and passed on to a recorder which transcribes the wave-signal onto a graph.

A radio telescope can "see" stars that give off no visible light or are so dim that they cannot be seen with an optical telescope. Radio telescopes can be used in any kind of weather because, unlike visible light waves, radio waves can travel through clouds. A telescope of this kind can also penetrate cosmic dust and gas clouds. However, the quality of the image generated by radio telescopes is not nearly as high as that of optical ones.

The largest radio telescope in the world is in Arecibo, Puerto Rico. Its antenna has a diameter of 305 meters (1,000 ft.). Other U.S. radio telescopes are located in Green Bank, WV; Socorro, NM; Ft. Irwin, AZ; and Owens Valley, CA.

Radio Telescope

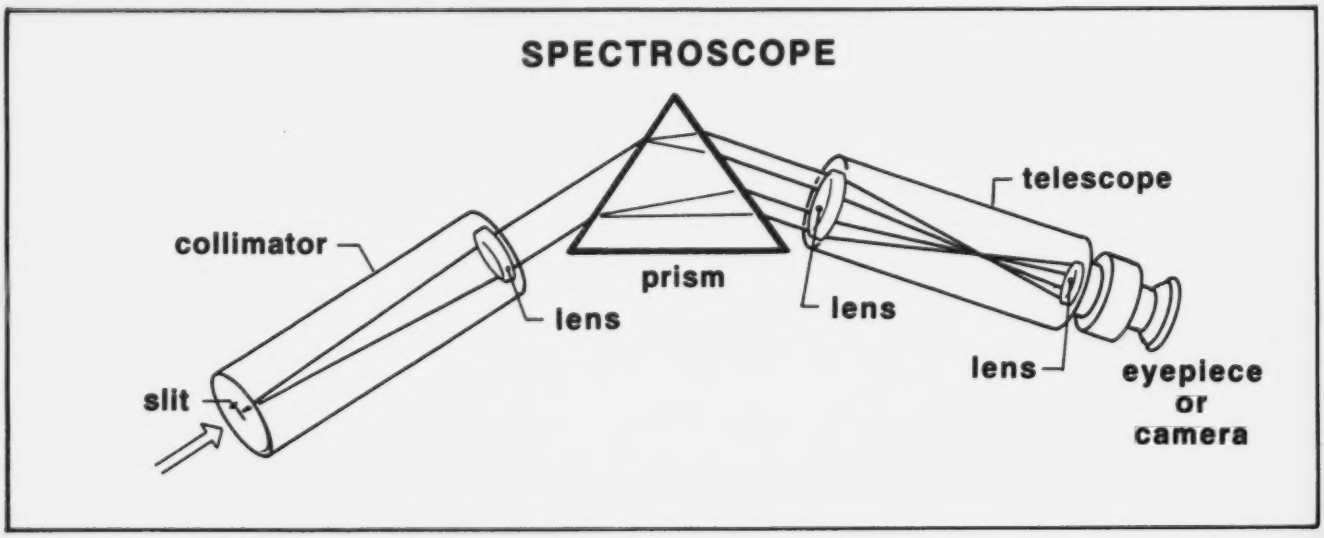
ACTIVITY Locate the major U.S. radio telescopes by marking their locations on the map with an X. What do you suppose the O marks indicate?

SPECTROSCOPES

Spectroscopes and spectrographs enable scientists to identify chemical elements in stars and planets. The composition of light received from heavenly bodies depends on the elements in the star or planet. Light rays passing through the telescope enter the **spectroscope** where a **prism** breaks the light rays into colors of the **spectrum.** When a camera is used with a spectroscope, the instrument is called a **spectrograph**. A long exposure on a photographic plate can reveal celestial bodies too faint to be seen with a telescope.

The computer has made it possible for astronomers to link a series of small telescopes all focused on the same object at the same time. The computer analyzes the energy received from each of the separate telescopes. As a result, the series of smaller telescopes is able to collect as much energy as a huge, single telescope in a more practical and economical manner. The **Very Large Array** (**VLA**) of twenty-seven 26-meter (83-ft) radio telescopes is an instrument used to make radio pictures of the sky with the resolution (quality of image) of optical telescopes. It is located in New Mexico.

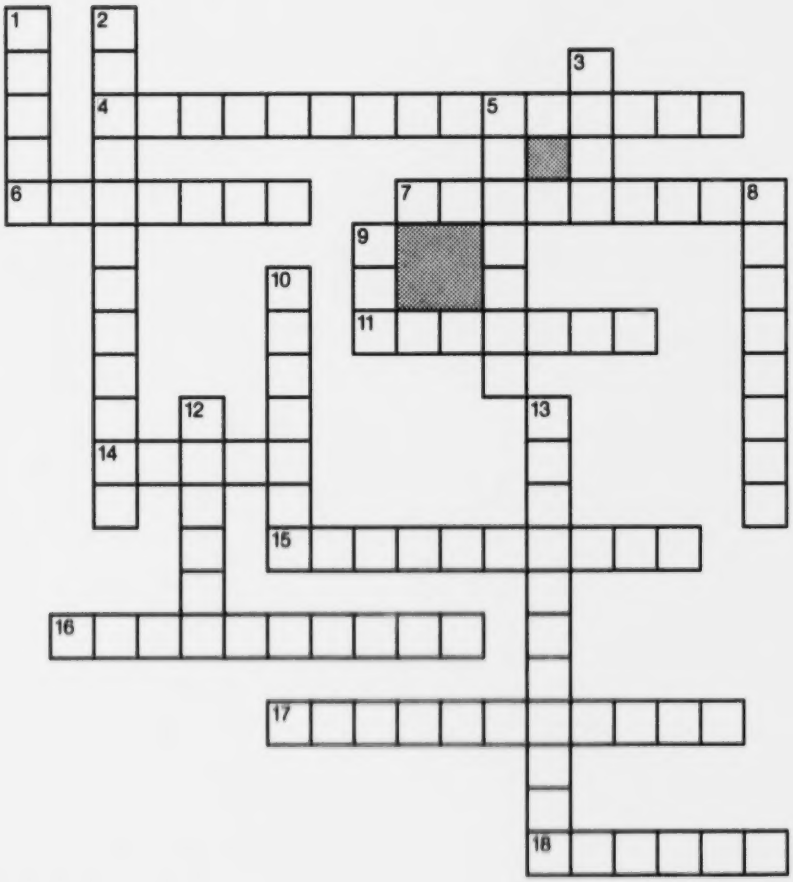
The surface of the earth is not a good place for setting up telescopes and related equipment for detecting gamma rays, x-rays, ultraviolet, and most infrared rays. This is true for the same reason Earth's living creatures are safe from deadly radiation: the atmosphere absorbs and scatters these types of energy. Consequently, telescopes and other detecting devices have been placed in orbit around the Earth, launched in balloons, or used in modified jet planes that can fly high enough to avoid the effects of Earth's atmosphere.



ACTIVITY The spectroscope measures shifts in the spectrum lines of a heavenly body. Find out what the "red shift" is and what astronomer Edwin Hubble discovered about it in 1929. Why was his discovery one of the most important in the world of astronomy?

TOOLS OF THE ASTRONOMER REVIEW

Review all of the material and diagrams on pages 21–24 before completing the crossword puzzle.



ACROSS

4. X-rays, gamma rays, and visible light are all kinds of _____ radiation.
6. kind of telescope that uses only visible light
7. instrument for viewing the heavens
11. part of radio telescope that receives signals
14. breaks light into colors of spectrum
15. Isaac Newton's telescope
16. Galileo's telescope
17. a building that houses telescopes
18. name of observatory in Wisconsin

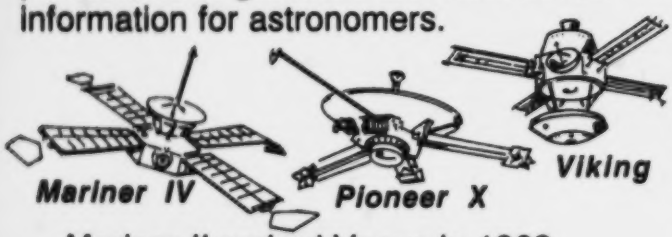
DOWN

1. A____ telescope sees objects too dim to be seen with optical telescopes.
2. an instrument for analyzing light from celestial bodies
3. The _____ in a telescope focuses the light and forms an image.
5. Italian astronomer who discovered four of Jupiter's moons
8. magnifies telescope image
9. series of linked telescopes
10. home of Hale telescope
12. In a reflecting telescope, a _____ reflects light and forms the image.
13. method of recording the location of stars

©MILLIKEN PUBLISHING COMPANY

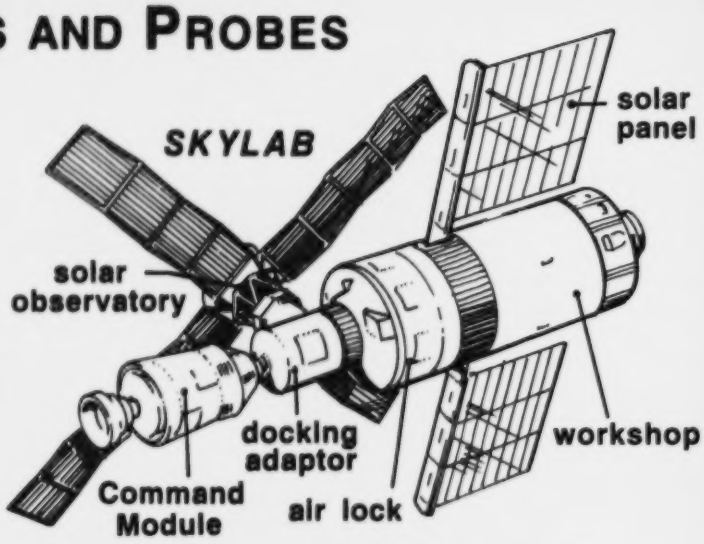
SATELLITES AND PROBES

Since the beginning of the space age in 1957 when the Soviet Union launched *Sputnik,* over 14,000 **satellites** have been launched. The National Aeronautics and Space Administration (**NASA**) has guided the United States space program. NASA has launched satellites for defense and communications purposes and for obtaining scientific information about Earth and the universe. **Probes**, which escape Earth's gravity to travel to other planets, have gathered the most useful information for astronomers.



Mariner II probed Venus in 1962. *Mariner IV* probed Mars in 1965. *Pioneer X* probed outer planets and continued beyond Pluto.

Skylab, America's first manned orbiting laboratory, was launched in 1973. At 432 km (270 mi) above Earth, Skylab used eight solar telescopes to view solar flares and prominences. After three missions, the unmanned



Skylab remained in orbit until 1979, then plunged back into Earth's atmosphere, burned, and left an 18,240 kilometer (11,400 mi) trail of debris in the Indian Ocean and parts of Australia.

In 1976, *Vikings I* and *II* accomplished the first successful landings on Mars. The data provided by *Viking* enabled scientists to make the most detailed analysis of Mars to date, but no signs of life were discovered.

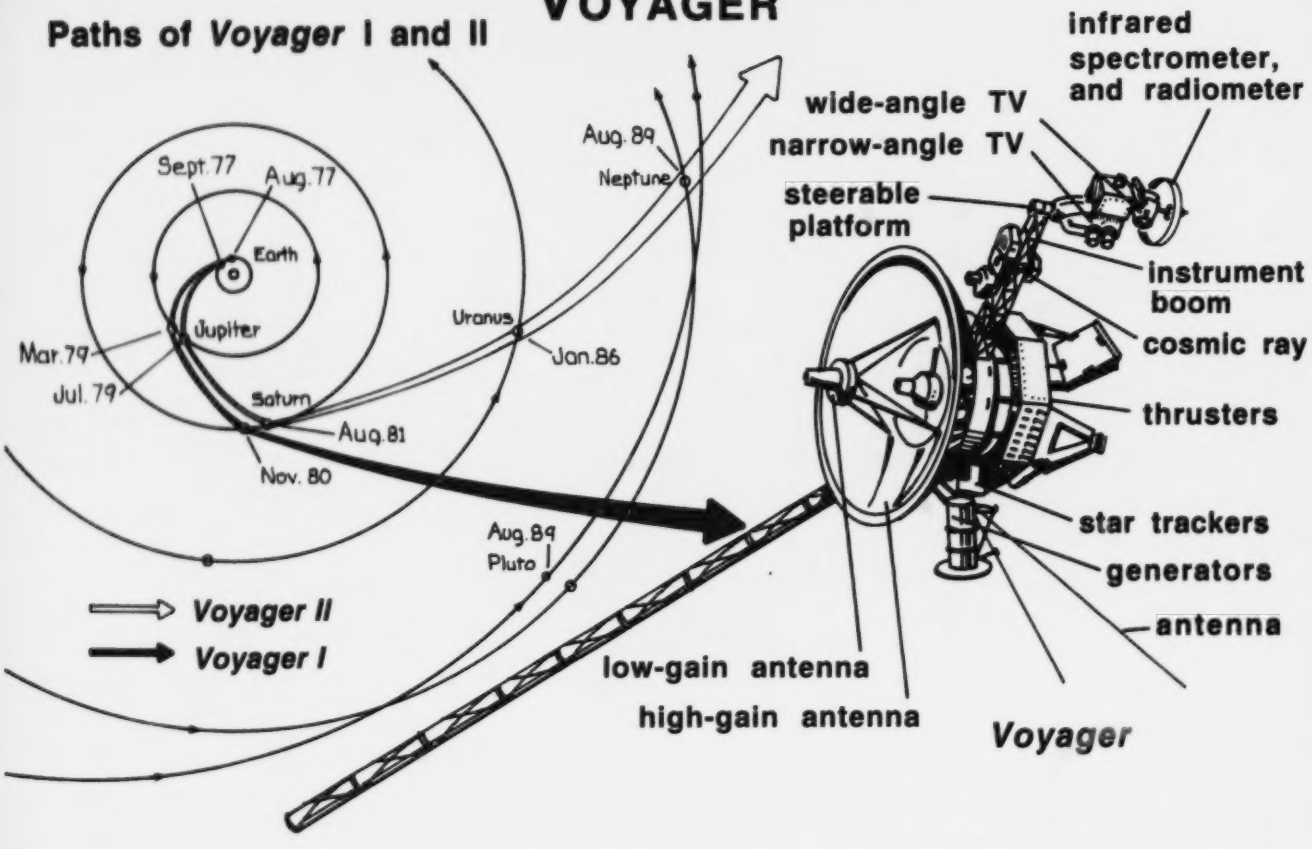
In 1989 NASA launched the *Magellan* probe, bound for an encounter with Venus in 1990, and the *Galileo* probe to Jupiter. A probe to Pluto, the only planet yet to be seen up close, may be launched in 2002.

ACTIVITY Draw a line to match the probe or satellite with its correct year and mission. Mark **P** beside each probe and **S** beside each satellite.

Probe or Satellite	Year	Mission
Mariner II	1965	to outer planets and beyond
Mariner IV	1976	first manned orbiting laboratory
Pioneer X	1973-76	first landing on Mars
Galileo	1962	to Venus
Skylab	1973-79	to Mars
Viking I	1989	to Jupiter

©MILLIKEN PUBLISHING COMPANY

VOYAGER



Two *Voyager* deep-space probes were launched in 1977 at a time when the planets were aligned in such a manner that the gravity of each planet they passed would boost the probes onward. Both have performed magnificently. In 1979 they sent back pictures of Jupiter, showing that it has a thin ring and a sixteenth moon. Most amazing of all was the discovery of active volcanoes on Io, one of Jupiter's moons.

When the *Voyagers* flew by Saturn in 1980 and 1981, the numerous photographs they relayed depicting Saturn's rings and satellites astounded scientists.

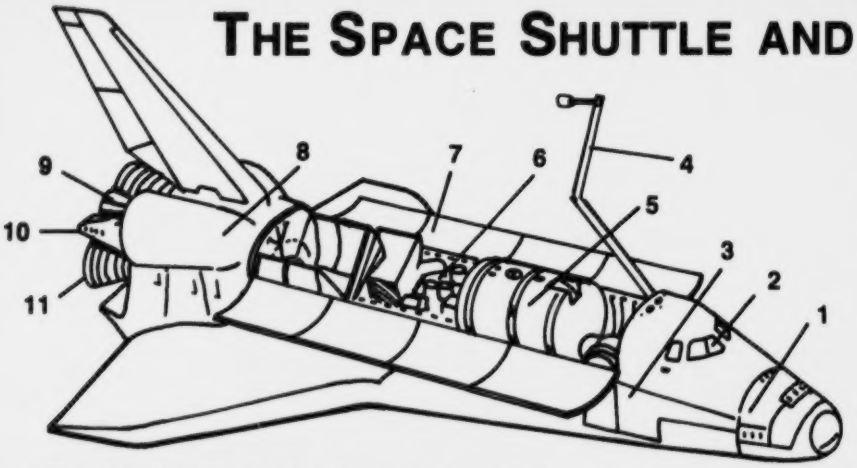
In 1986 *Voyager II* reached Uranus and raised the number of this planet's known moons from five to fifteen. *Voyager's* photographs also revealed two more rings.

Voyager II amazed scientists again when it flew by Neptune in August 1989, sending back spectacular photos of six previously unknown moons and a faint ring system.

ACTIVITY Write a report on one or two articles about a current NASA satellite mission.

©MILLIKEN PUBLISHING COMPANY

THE SPACE SHUTTLE AND BEYOND



1. forward control thrusters
2. flight deck
3. mid-deck (living area)
4. manipulator arm
5. spacelab
6. payload bay
7. payload bay doors
8. fuel tanks
9. maneuvering engines
10. aft control thrusters
11. main engines

The 1980s brought the successful initial flights of the United States' space shuttle, the world's first reusable spacecraft. Each of the United States' orbiters has a 100-mission life. The crews of the four orbiters—*Columbia, Challenger, Discovery, and Atlantis*—have carried out important astronomical and scientific observations. In addition, they have deployed communication satellites and conducted military and medical experiments in space.

In 1980 the Solar Maximum Mission Observatory was launched, but a few months later it malfunctioned. The 1984 crew of a *Challenger* flight retrieved the satellite, made the necessary repairs, and relaunched the satellite. This was a first in space research history. On this same mission, *Challenger* carried the first U.S. woman, astronaut Sally Ride, into space.

The fourth shuttle orbiter, *Atlantis,* was launched successfully in 1985. Then, on January 28, 1986, less than 74 seconds into its ninth flight, the *Challenger* shuttle experienced a malfunction and exploded, killing all seven crew members. This disaster resulted in intense investigations and caused NASA to halt the shuttle program until an improved shuttle could be developed.

NASA resumed shuttle operations in 1988 with successful launches of the STS26 *Discovery*.

In 1996, NASA is scheduled to begin construction of a space station. There, rocket ships can be assembled and launched—possibly to carry people throughout the solar system . . . and beyond.

Review pages 26–28. Answer these questions on another paper.

1. In what year was *Sputnik* launched?
2. What satellite probed Mars?
3. What was the mission of *Pioneer* X?
4. What was America's first orbiting laboratory called?
5 What satellites were launched at the same time?
6. What discovery was made in 1979 regarding Io, Jupiter's moon?
7. What satellite flew by Neptune in 1989?
8. Name the current three orbiters of the United States' space shuttle.
9. Who was the first American woman in space?
10. How many missions is each shuttle orbiter designed to carry out?

Environmental Series
Flexible Formats...Designed for You

We know educators have individual teaching styles. That's why our environmental series has been designed for the way you teach. For each title, you can choose from the following formats:

Poster Book—Includes four 17" x 22" color posters, 12 reproducible pages, and four teacher resource pages.

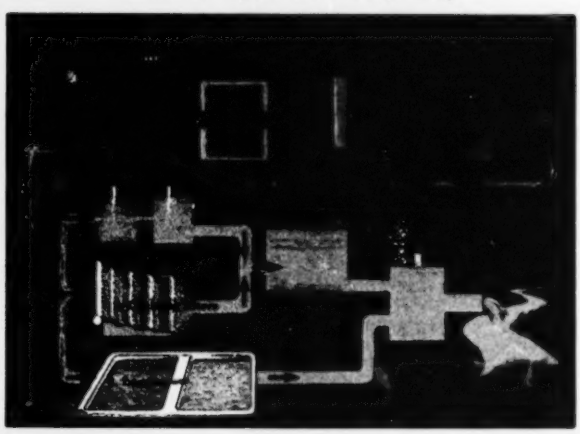
Transparency/Reproducible Book—Includes four transparencies, 12 reproducible pages, and four teacher resource pages.

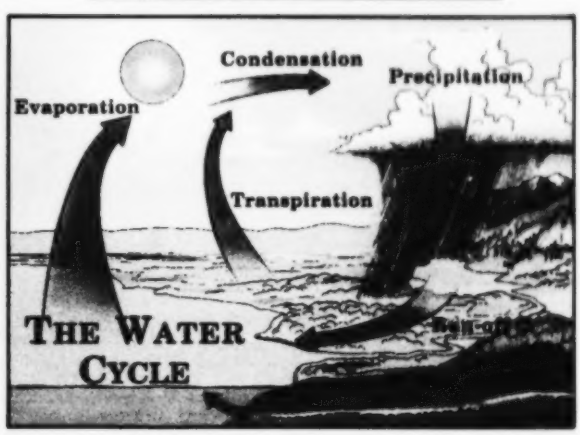
Study Print—Includes four 13" x 18" colorful prints with background information, 12 reproducible pages, and four teacher resource pages.

$7.95 each

This environmental series was developed to assist teachers with environmental education and to help lead discussions on environmental problems and their causes, alternatives to solving environmental issues, and individual values.

*Shown are three posters from the Water Quality and Pollution package.

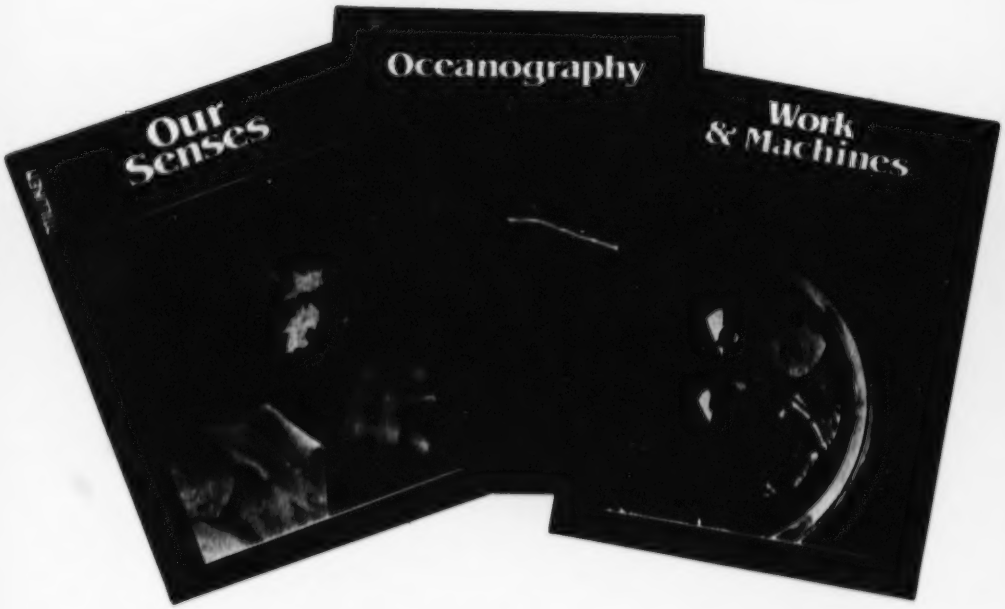




Six Titles:	Poster	Study Print	Trans/Repro
1. Air Quality and Pollution	MP5001	MP4513	MP4701
2. Water Quality and Pollution	MP5002	MP4514	MP4702
3. Land Resources and Pollution	MP5003	MP4515	MP4703
4. Energy and the Environment	MP5004	MP4516	MP4704
5. Wildlife Resources	MP5005	MP4517	MP4705
6. Human Population and Resources	MP5006	MP4518	MP4706

Quality...that's Milliken's Science Series...

Clear, concise illustrations at your students' fingertips. Deliver lessons with greater impact with these easy-to-use, information/activity pages. Comprehensive background information for teachers. Answers for review pages.



Reproducible Books		Duplicating Books
MP3131	PLANTS	MP2111
MP3132	ANIMALS	MP2112
MP3133	BODY SYSTEMS	MP2113
MP3134	ECOLOGY	MP2114
MP3135	PLANET EARTH	MP2115
MP3136	SOLAR SYSTEM	MP2116
MP3137	OCEANOGRAPHY	MP2117
MP3138	WEATHER	MP2118
MP3139	SIMPLE CHEMISTRY	MP2119
MP3140	SOLIDS, LIQUIDS, & GASES	MP2120
MP3141	MAGNETISM & ELECTRICITY	MP2121
MP3142	CLASSIFICATION	MP2122
MP3143	OUR SENSES	MP2123
MP3144	NUTRITION & HEALTH	MP2124
MP3145	WORK & MACHINES	MP2125
MP3146	PREHISTORIC LIFE	MP2126
MP3147	SMALL LIVING THINGS	MP2127
MP3148	EXPLORING THE UNIVERSE	N/A
MP3149	LIGHT & SOUND	N/A
MP3150	FLIGHT	N/A

0 50487 02811 0